

Faculty of Cognitive Sciences and Human Development

Collaborative Learning of Year 4 Science Subject Using Board Games

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Collaborative Learning of Year 4 Science Subject Using Board Games

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A thesis submitted

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

In an educational landscape increasingly influenced by technology, this research investigates collaborative gaming using a digital and non-digital format to uncover their potential to elevate students' academic performance, learning motivation, and social interaction within the Science classroom. This research employs a pre-test-post-test between-groups design to investigate the gender differences and the effectiveness of Conventional Teaching (CT), Collaborative Learning (CL) strategies in the context of teaching the Year 4 Science curriculum through Paper-Based Board Games (PBBG) and Computerized Board Games (CBG). The study engages a diverse group of 10-year-old participants from National-Type Chinese Primary Schools to comprehensively analyze the gender differences by comparing the change scores and mean scores for CT with the PBBG and CBG. Through a combination of quantitative methods encompassing pre-tests, post-tests, and questionnaires, while qualitative approaches involve classroom observations and interviews, the distinction of CT, PBBG and CBG with CL is explained. The findings reveal that there are no gender differences between teaching methods. In contrast, a significant difference was detected between the academic performance, social interaction and learning motivation, facets of CT, PBBG, and CBG, specifically in science education. Notably, the PBBG group exhibits a higher mean score and lower standard deviation, implying a more robust perception of academic performance, social interaction and learning motivation. The implications of this research reverberate across the educational landscape, offering valuable insights to educators, curriculum designers, and educational technology developers in pursuing innovative Science education approaches. Recognising the inherent value of PBBG and CBG, with CL, educators are poised to harness their potential to create engaging and impactful learning experiences for 10-year-old participants

within National-Type Chinese Primary Schools. This approach enhances their grasp of scientific concepts while nurturing essential collaborative skills.

Keywords: Conventional Teaching (CT), Paper-Based Board Games (PBBG), Computerized Board Game (CBG), Collaborative Learning (CL), academic performance, learning motivation, social interaction, 10-year-old participants, National-Type Chinese Primary Schools

Pembelajaran Kolaboratif Mata Pelajaran Sains Tahun 4 Menggunakan Permainan Papan Berkomputer dan Permainan Papan Berdasarkan Kertas

ABSTRAK

Dalam landskap pendidikan yang semakin dipengaruhi oleh teknologi, kajian ini menyiasat permainan kolaboratif menggunakan format digital dan bukan digital untuk mendedahkan potensi mereka untuk meningkatkan prestasi akademik, motivasi pembelajaran dan interaksi sosial pelajar dalam kelas Sains. Kajian ini menggunakan reka bentuk pra-ujian-pasca antara kumpulan untuk menyiasat perbezaan jantina, dan keberkesanan strategi Pengajaran Tradisional (PT), Pembelajaran Kolaboratif (PK) dalam konteks pengajaran kurikulum Sains Tahun 4 melalui Permainan Papan Berdasarkan Kertas (PPBK) dan Permainan Papan Berkomputer (PPB). Kajian ini melibatkan sekumpulan peserta berumur 10 tahun yang pelbagai dari Sekolah Rendah Cina Jenis Kebangsaan untuk menganalisis secara komprehensif perbezaan jantina, sebagai membandingkan skor perubahan dan skor min untuk PT dengan PPBK dan PPB. Melalui gabungan kaedah kuantitatif yang merangkumi ujian pra, ujian pasca dan soal selidik, manakala pendekatan kualitatif melibatkan pemerhatian dan temu bual bilik darjah, perbezaan PT, PPBK dan PPB, dengan PK dijelaskan. Dapatan kajian menunjukkan bahawa tiada perbezaan jantina antara kaedah pengajaran yang terlibat. Sebaliknya, perbezaan yang signifikan dikesan antara prestasi akademik, interaksi sosial dan motivasi pembelajaran, aspek PK, PPBK dan PPB, khususnya dalam pendidikan Sains. Kumpulan PPBK mempamerkan skor min yang lebih tinggi dan sisihan piawai yang lebih rendah, menunjukkan persepsi yang lebih mantap terhadap prestasi akademik, interaksi sosial dan motivasi pembelajaran. Implikasi kajian ini bergema merentasi landskap pendidikan, menawarkan pandangan berharga kepada pendidik, pereka

kurikulum dan pembangun teknologi pendidikan dalam mengikuti pendekatan pendidikan Sains yang inovatif. Menyedari nilai semula jadi PPBK dan PPB, dengan PK, para pendidik bersedia untuk memanfaatkan potensi mereka untuk mencipta pengalaman pembelajaran yang menarik dan memberi kesan untuk peserta berumur 10 tahun dalam Sekolah Rendah Cina Jenis Kebangsaan. Pendekatan ini meningkatkan pemahaman mereka tentang konsep saintifik sambil memupuk kemahiran kolaboratif yang penting.

Kata kunci: *Permainan Papan Berdasarkan Kertas (PPBK), Permainan Papan Berkomputer (PPB), Pembelajaran Kolaboratif (PK), pencapaian akademik, motivasi pembelajaran, interaksi sosial, peserta berusia 10 tahun, Sekolah Jenis Kebangsaan Cina*

TABLE OF CONTENTS

		Page
DECLARATION		i
ACKNOWLEDGEMENT		ii
ABSTRACT		iii
ABSTRAK		vii
TABLE OF CONTENTS		viii
LIST OF TABLES		xxvi
LIST OF FIGURES		xx
LIST OF ABBREVIATIONS		xxiii
CHAPTER 1: INTRODUCTION		**1**
1.1	Introduction	1
1.2	Background of the Study	5
1.3	Problem Statements	11
1.4	Research Objectives	20
1.5	Research Questions	21
1.6	Research Hypotheses	21
1.7	Significance of the Research	23
1.8	Definitions of Terms	26

1.8.1 Science Classroom 26

1.8.2 Pupils 27

1.8.3 Collaborative Learning (CL) 27

1.8.4 Conventional Teaching (CT) 29

1.8.5 Computerized Board Games (CBG) 30

1.8.6 Paper-Based Board Games (PBBG) 30

1.8.7 Learning Motivation 31

1.8.8 Social Interaction 32

1.9 Summary 33

CHAPTER 2: REVIEW OF LITERATURE 34

2.1 Introduction 34

2.2 Malaysia Education Blueprint 2013 - 2025 35

2.2.1 STEM Education 36

2.2.2 Revised Version of Standard-Based for Primary Schools 37

2.2.3 Science Classroom 38

2.3 Teaching and Learning Approaches in Science Education 41

2.3.1 Inquiry-Based Science Learning 41

2.3.2 Conventional Teaching (CT) 41

2.3.3 Computer-Supported Collaborative Learning (CSCL) 42

2.3.3.1 Collaborative Learning (CL) 43

2.4 Social Interaction in the Classroom 45

2.5 Gamification in the Education Field 49

2.5.1 Paper-Based Board Games (PBBG) 49

2.5.2 Computerized Board Games (CBG) 59

2.6 Gender Differences 64

2.6.1 Conventional Teaching (CT) 64

2.6.2 Paper-Based Board Games (PBBG) 67

2.6.3 Computerized Board Games (CBG) 69

2.7 Learning Motivation in Science Learning 71

2.8 Suggested Theories 73

2.8.1 Activity Theory (AT) 73

2.8.2 Social Constructivisim Theory (SCT) 78

2.9 Theoretical Framework 81

2.10 Summary 84

CHAPTER 3: DESIGN AND DEVELOPMENT 86

3.1 Introduction 86

3.2 AGILE System Dveleopment 86

3.2.1 Definition 86

3.2.2 The 12 Principles of AGILE System Development 90

3.2.3 Benefits of AGILE Development 95

3.2.4 Framework of AGILE Development 96

3.3 Design and Development of Board Games 100

3.3.1 Paper-Based Board Games (PBBG) 100

3.3.2 Computerized Board Games (CBG) 117

3.4 Playtesting the Board Games 131

3.4.1 Paper-Based Board Games (PBBG) 131

3.4.2 Computerized Board Games (CBG) 135

3.5 Possible Changes and Improvements 138

3.5.1 Paper-Based Board Games (PBBG) 138

3.5.2 Computerized Board Games (CBG) 141

3.6 Further Potential for Future Development 143

3.6.1 Paper-Based Board Games (PBBG) 143

3.6.2 Computerised Board Games (CBG) 144

3.7 Summary 146

CHAPTER 4: METHODOLOGY **148**

4.1 Introduction 148

4.2 Research Design 149

4.3 Populations and Sampling 150

4.4 Ethical Considerations 155

4.4.1 Informed Consent 155

4.4.1.1 Informed Consent: Students 156

4.4.1.2 Informed Consent: Parents 158

4.4.1.3 Application for Conducting the Research to the Selected Tuition Centre 159

4.4.2 Privacy and Confidentiality 159

4.4.3 Data Storage 160

4.4.4 Minimising Disruption 161

4.5 Validity and Reliability 162

4.5.1 PowerPoint Presentation Slides 165

4.5.2 Paper-Based Board Games (PBBG) 166

4.5.3 Computerized Board Games (CBG) 167

4.5.4 Pre-Test and Post-Test 167

4.5.5 Questionnaire 169

4.5.6 Classroom Observation Protocol 171

4.5.7 Interview Protocol 172

4.6 Research Instruments 173

4.6.1 Computerized Board Games (CBG) 174

4.6.2 Paper-Based Board Games (PBBG) 175

4.6.3 Pre-Test and Post-Test 175

4.6.4 Questionnaire 179

4.6.5 Classroom Observation 183

4.6.6 Interview 185

4.7 Research Procedures 193

4.8 Data Analysis 197

4.8.1 Gender Differences 198

4.8.2 Pre-Test and Post-Test 198

4.8.3 Questionnaire 199

4.8.4 Classroom Observation Protocol 200

4.8.5 Interview Protocol 200

4.9 Summary 201

CHAPTER 5: PILOT STUDY 203

5.1 Introduction 203

5.2 Research Hypotheses 204

5.3 Research Procedures 205

5.4 Data Analysis 208

5.4.1 Assessment of Normality 209

5.4.1.1 Gender Differences 209

5.4.1.2 Pre-test and Post-test 210

5.4.1.3 Questionnaire 210

5.5 Results and Findings of Pilot Study 211

5.5.1 How do genders differ between PBBG and CBG in learning Science among

10-year-old participants? 211

5.5.2 How do pre-test and post-test scores differ between PBBG and CBG in learning Science among 10-year-old participants? 218

5.5.3 How does social interaction differ between PBBG and CBG in learning Science among 10-year-old participants? 219

5.5.4 How does learning motivation differ between PBBG and CBG in learning Science among 10-year-old participants? 222

5.5 Summary 225

CHAPTER 6: RESULTS 227

6.1 Introduction 227

6.2 Respondents' Demographic Profiles 228

6.3 Findings of the Research 229

6.3.1 How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 230

6.3.2 How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 236

6.3.3 How does social interaction differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 244

6.3.4 How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 270

6.4 Summary 306

CHAPTER 7: DISCUSSIONS 308

7.1 Introduction 308

7.2 Gender Differences between CT, PBBG and CBG in Learning Science among 10-year-old Participants 308

7.3 Differences in Pre-test and Post-test Scores between CT, PBBG and CBG in Learning Science among 10-year-old Participants 311

7.4 Differences in Social Interaction between CT, PBBG and CBG in Learning Science among 10-year-old Participants 318

7.5 Differences in Learning Motivation between CT, PBBG and CBG in Learning Science among 10-year-old Participants 323

7.6 Summary 330

CHAPTER 8: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS 331

8.1 Introduction 331

8.2 Summary of the Findings 332

8.2.1 How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 333

8.2.2 How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 333

8.2.3 How does social interaction differ between CT, PBBG and CBG in learning

Science among 10-year-old participants? 334

8.2.4 How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants? 335

8.3 Conclusion of the Research 336

8.4 Implication of the Research 337

8.4.1 Practical Implications 338

8.4.2 Theoretical Implications 342

8.5 Limitations of the Research 343

8.6 Recommendation for Future Research 347

8.7 Summary 356

REFERENCES **358**

APPENDICES **442**

LIST OF TABLES

		Page
Table 4.1	Gender Distribution of 10-year-old participants Who Were Exposed to PowerPoint Presentation	152
Table 4.2	Gender Distribution of 10-year-old participants Who Were Exposed to PBBG with CL	153
Table 4.3	Gender Distribution of 10-year-old participants Who Were Exposed to CBG with CL	154
Table 4.4	The standards of Cohen Kappa's Inter-rater reliability of the tests	164
Table 4.5	Frequency and Percentages for Teacher A and Teacher B in Rating the Questions from Both Pre-test and Post-test	169
Table 4.6	Frequency and Percentages for Teacher A and Teacher B in Rating the Questionnaires	171
Table 4.7	Frequency and Percentages for Teacher A and Teacher B in Rating the Classroom Observation Protocol	172
Table 4.8	Frequency and Percentages for Teacher A and Teacher B in Rating the Interview Protocol	173
Table 4.9	Results of the Reliability Test toward Three Science Topics for Pre-Test and Post-test	178
Table 4.10	Results of the Reliability Test Toward Learning Motivation and Social Interaction in the Questionnaire Instruments	183
Table 4.11	Revised Version of the Interview Protocol in Implementing PBBG after Discussion with Two Experienced Science Teachers	187
Table 4.12	Revised Version of the Interview Protocol in Implementing CBG after Discussion with Two Experienced Science Teachers	190
Table 4.13	Results of the Reliability Test toward Interview Protocol Instruments after Implementing PBBG and CBG	193
Table 5.1	Standard for Mean Value	209
Table 5.2	Tests of Normality for change scores after implementing PBBG among 10-year-old participants	212
Table 5.3	Results of Independent Sample t-test for change scores after implementing PBBG among 10-year-old participants	212

Table 5.4	Tests of Normality for change scores after implementing CBG among 10-year-old participants	213
Table 5.5	Results of Independent Sample t-test for change scores after implementing CBG among 10-year-old participants	214
Table 5.6	Tests of Normality for social interaction after implementing PBBG among 10-year-old participants	214
Table 5.7	Results of the Mann-Whitney U for social interaction mean scores after implementing PBBG among 10-year-old participants	215
Table 5.8	Tests of Normality for social interaction mean scores after implementing CBG among 10-year-old participants	215
Table 5.9	Results of Independent Sample t-test for social interaction mean scores after implementing CBG among 10-year-old participants	216
Table 5.10	Tests of Normality for learning motivation mean scores after implementing PBBG among 10-year-old participants	216
Table 5.11	Results of the Mann-Whitney U test for learning motivation mean scores after implementing PBBG among 10-year-old participants	217
Table 5.12	ests of Normality for learning motivation mean scores after implementing CBG among 10-year-old participants	217
Table 5.13	Results of Mann-Whitney U test for learning motivation mean scores after implementing CBG among 10-year-old participants	217
Table 5.14	Tests of Normality for pre-test and post-test test after implementing PBBG and CBG among the 10-year-old participants for the "Subtopic 5.1: Light Travels in a Straight Line "	218
Table 5.15	Results of Wilcoxon Signed Rank test for subtopic "Light Travels in a Straight Line" towards pre-test and post-test scores between PBBG and CBG groups	219
Table 5.16	Mean score interpretation for social interaction in learning science using PBBG and CBG among 10-year-old participants	219
Table 5.17	Tests of Normality for social interaction after implementing PBBG and CBG among the 10-year-old participants	220
Table 5.18	Results of Wilcoxon Signed Rank test for the mean scores of social interactions between PBBG and CBG groups	220
Table 5.19	Mean score interpretation for social interaction in learning science using PBBG and CBG among 10-year-old participants	222

Table 5.20	Tests of Normality for learning motivation after implementing PBBG and CBG among 10-year-old participants	223
Table 5.21	Results of Wilcoxon Signed Rank test for the mean scores of learning motivation between PBBG and CBG groups	223
Table 6.1	CT Group	228
Table 6.2	PBBG Group	229
Table 6.3	CBG Group	229
Table 6.4	Results of the Mann-Whitney U test toward change scores for the gender differences in the CT group	230
Table 6.5	Results of the Mann-Whitney U test toward change scores for the gender differences in the PBBG group	231
Table 6.6	Results of the Mann-Whitney U test toward change scores for the gender differences in the CBG group	232
Table 6.7	Results of the Mann-Whitney U test toward mean scores of social interaction for the gender differences in the PBBG group	232
Table 6.8	Results of the Mann-Whitney U test toward mean scores of social interaction for the gender differences in the CBG group	233
Table 6.9	Results of the Mann-Whitney U test toward mean scores of learning motivation for the gender differences in the PBBG group	233
Table 6.10	Results of the Mann-Whitney U test toward mean scores of learning motivation for the gender differences in the CBG group	234
Table 6.11	Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Properties of Light"	237
Table 6.12	Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Energy"	238
Table 6.13	Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Materials"	239
Table 6.14	Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for Three Science Topics	240

Table 6.15	Results of the Kruskall-Wallis test for change scores from pre-test to post-test between CT, PBBG and CBG groups	241
Table 6.16	Kruskal-Wallis Dunn's Post Hoc Test results for change scores between CT, PBBG and CBG groups	242
Table 6.17	Mean Score Interpretation for Social Interaction in Learning Science using CT, PBBG and CBG among 10-year-old participants	245
Table 6.18	Tests of Normality for Social Interaction after Implementing CT, PBBG and CBG among the 10-year-old participants	246
Table 6.19	Results of the Kruskall-Wallis test for mean scores of social interaction between CT, PBBG and CBG groups	247
Table 6.20	Kruskal-Wallis Dunn's Post Hoc Test results for mean social interaction scores between CT, PBBG and CBG groups	248
Table 6.21	Definition and Labels for Selected Themes	258
Table 6.22	Mean Score Interpretation for Learning Motivation (Self-Challenge) in Learning Science using CT, PBBG and CBG among 10-year-old participants	270
Table 6.23	Mean Score Interpretation for Learning Motivation (Self-Confidence) in Learning Science using CT, PBBG and CBG among 10-year-old participants	271
Table 6.24	Mean Score Interpretation for Learning Motivation (Assessment) in Learning Science using CT, PBBG and CBG among 10-year-old participants	272
Table 6.25	Mean Score Interpretation for Learning Motivation Dimension in Learning Science using CT, PBBG and CBG among 10-year-old participants	273
Table 6.26	Mean Score Interpretation for Learning Motivation in Learning Science using CT, PBBG and CBG among 10-year-old participants	274
Table 6.27	Tests of Normality for Learning Motivation after Implementing CT, PBBG and CBG among the 10-year-old participants	275
Table 6.28	Results of the Kruskall-Wallis test for mean scores of learning motivation between CT, PBBG and CBG groups	276
Table 6.29	Kruskal-Wallis Dunn's Post Hoc Test results for mean learning motivation scores between CT, PBBG and CBG groups	276
Table 6.30	Codes and the Corresponding Themes	288

LIST OF FIGURES

		Page
Figure 1.1	The Framework of Standard-Based Curriculum for Primary School	6
Figure 1.2	Excerpt of a Constant Standard from the Primary School Standard Curriculum (Revised) for Year 4 Science	7
Figure 2.1	Hierarchical Levels of an Activity (Leont've, 1981)	74
Figure 2.2	Engestrom's Expanded Activity Theory Model (Engestrom, 1987)	76
Figure 2.3	Proposed Theoretical Framework of General Concepts	82
Figure 3.1	Adapted AGILE Design Process from Unger & Novak (2011)	98
Figure 3.2	Prototype for First Draft of PBBG "*SciFun* Board Game"	104
Figure 3.3	First Draft of PBBG "*SciFun* Board Game"	105
Figure 3.4	Prototype for First Draft of "Total Point Reward" Scoreboard	107
Figure 3.5	First Draft of "Total Point Reward" Scoreboard	107
Figure 3.6	Instructions for Playing PBBG in MS Word File	108
Figure 3.7	Prototype for Second Draft of PBBG "*SciFun* Board Game"	109
Figure 3.8	Second Draft of PBBG "*SciFun* Board Game"	110
Figure 3.9	Prototype for Second Draft of "Total Point Reward" Scoreboard	111
Figure 3.10	Finalized Version of "Total Point Reward" Scoreboard	112
Figure 3.11	Instructions for Playing PBBG in MS PowerPoint File	113
Figure 3.12	Prototype for Third Draft of PBBG "*SciFun* Board Game"	114
Figure 3.13	Finalized Version of PBBG "*SciFun* Board Game"	116
Figure 3.14	Prototype for First Draft of CBG "*SciFun* Board Game"	119
Figure 3.15	First Draft of CBG "*SciFun* Board Game"	120
Figure 3.16	Prototype for First Draft of "Total Point Reward" Scoreboard	121
Figure 3.17	First Draft of "Total Point Reward" Scoreboard	122

Figure 3.18 Instructions for Playing CBG in MS Word File 122

Figure 3.19 Prototype for Second Draft of CBG "*SciFun* Board Game" 123

Figure 3.20 Second Draft of CBG "*SciFun* Board Game" 125

Figure 3.21 Prototype for Second Draft of "Total Point Reward" Scoreboard 126

Figure 3.22 Finalized Version of "Total Point Reward" Scoreboard 126

Figure 3.23 Instructions for Playing CBG in MS PowerPoint File 128

Figure 3.24 Prototype for Third Draft of CBG "*SciFun* Board Game" 129

Figure 3.25 Finalized Version of CBG "*SciFun* Board Game" 131

Figure 6.1 Themes and Its Subthemes for Social Interaction through Classroom Observation 250

Figure 6.2 Themes and Its Subthemes for Learning Motivation through Classroom Observation 279

LIST OF ABBREVIATIONS

AR	Augmented Reality
ASATSC	Asian Student Attitudes towards Science Class
AT	Activity Theory
CBG	Computerized Board Games
CL	Collaborative Learning
CSCL	Computer-Supported Collaborative Learning
CT	Conventional Teaching
DSKP	*Dokumen Standard Kurikulum Dan Pentaksiran*
HOTs	Higher Order Thinking Skills
IBSE	Inquiry-Based Science Education
IoT	Internet of Things
IR 4.0	Industrial Revolution 4.0
IS	Importance of Science
MCSCL	Mobile Computer-Supported Collaborative Learning
MOE	Ministry of Education
MSLQ	Motivated Strategies for Learning Questionnaire
PBBG	Paper-Based Board Games
PISA	Program for International Student Assessment
PLC	Professional Learning Community
SC	Science Confidence
SCT	Social Constructivism Theory
SE	Science Enjoyment

SPSS	Statistical Package of Social Science
STEM	Science, Technology, Engineering and Mathematics
TEAL	Technology-Enabled Active Learning
TEBG	Technology-Enhance Board Game
TIMSS	Trends in International Mathematics and Science Study
TMBI	Technology Enhanced Model-Based Instruction
TOS	Table of Specification
UI	User Interface
UNIMAS	University Malaysia Sarawak
VR	Virtual Reality
ZPD	Zone of Proximal Development

CHAPTER 1

INTRODUCTION

1.1 Introduction

Despite ongoing policy changes in the education system, the Malaysian government is unwavering in increasing students' enrolment in Science and Technology (Rashid, 2021). The government has implemented strategic advances to encourage students to pursue Science subjects, including the National Education Policy, 3rd Core of Eleventh Malaysia Plan, and Malaysia Education Blueprint 2013 – 2025 (Abdullah, 2021). These initiatives are guided by five main aspirations: Access, Quality, Equity, Unity, and Efficiency, as outlined by the Ministry of Education in 2012.

One of the eleven shifts in the Malaysian Education System is dedicated to science education, aiming to achieve specific aspirations. Shift 1 focuses on providing equal access to quality education of an international standard and transforming teaching into the profession of choice. To fulfil Shift 1, a key policy is to benchmark the learning of Mathematics and Science to international standards. As part of this effort, revisions have been made to the Standard-Based Curriculum for Primary Schools, implemented from 2017 to 2022, for science subjects in Year 1 to Year 6 (Sulaiman et al., 2017).

Another policy aims to enhance the quality of Science, Technology, Engineering, and Mathematics (STEM) education in Malaysia. The Ministry of Education (MOE) has established goals to foster a scientific, progressive, inventive, and forward-thinking society capable of utilizing cutting-edge technologies. These objectives are pursued by

implementing a new curriculum that develops critical, creative, innovative, and skilled citizens with expertise in STEM fields (Jamel et al., 2019).

The National STEM Centre was established to promote the 5E Inquiry Learning for Science pedagogical approach. This approach involves engaging, exploring, explaining, elaborating, and evaluating phases, enabling students to restructure their pre-instructional conceptions in alignment with school Science perspectives (Ong et al., 2021).

Science holds significant importance in STEM education. The Ministry of Education (MOE) has made it mandatory for students in Years 1 to 3 (Level 1) and Years 4 to 6 (Level 2) of primary education in Malaysia, regardless of school type or language of instruction (Mahmud et al., 2018). Science continues to be compulsory for secondary school students in Forms 1 to 3 (Lower Secondary) and those who have chosen not to pursue pure Science classes in Forms 4 and 5 (Upper Secondary).

MOE has developed various digital resources to assist school teachers in their classroom teaching and learning activities. To highlight the importance of STEM education, one of the key digital resources focuses on "Higher Order Thinking Skills (HOTs)." Teachers can access these resources from the Ministry's official website, which includes materials such as HOTs: Higher Order Thinking Skills in Schools Initiative, Higher Order Thinking Skills: School Applications, HOTs Elements in the Curriculum, HOTs Elements in Pedagogy, Exemplary Items in Assessing Higher Order Thinking in Primary Schools, and Exemplary Items in Assessing Higher Order Thinking in Secondary Schools: Science and Mathematics Areas (Ong, 2022).

The inclusion of specific topics in the primary Science curriculum calls for teachers to develop active and meaningful Science teaching and learning methods, given the

emphasis on STEM education in the current educational context (Adam & Halim, 2019). In response, inquiry-based Science teaching has emerged as one of the highly emphasised 21st-century teaching approaches to foster students' interest and engagement in Science learning (Ab Hakim & Iksan, 2018).

The worldwide adoption of inquiry-based Science teaching, including in Malaysia, has been observed (Ibrahim & Mahmud, 2020). Science teachers use this approach to prepare students for 21st-century learning and effectively grasp scientific processes and concepts. This approach is further reinforced by Former Senior Minister of Education, YB Datuk Dr. Radzi Jidin, who highlights the Ministry of Education's continuous efforts in organising various STEM competency development programs, such as Inquiry-Based Science Education (IBSE), which emphasises the integration of HOTs in Science learning (Strat et al., 2023).

In the Malaysia Education Development Plan 2013 – 2015, inquiry skills are essential because they help students develop various high-order thinking skills, including scientific, soft, information technology, problem-solving, and decision-making skills. The plan supports several inquiry-based teaching methods, including project-based learning, scientific investigation, problem-based learning, Collaborative Learning (CL), lesson study (Iksan et al., 2018), and case study (MOE, 2016; Sikas, 2017).

Technology integration in the education system has facilitated and supported CL among school students (Järvenoja, 2020). CL, an inquiry-based teaching method in Malaysia, enhances students' social climate and academic performance (Ghavifekr, 2020), stimulates higher-order thinking skills, boosts incentives, and strengthens interpersonal relationships (Le et al., 2018; Pang et al., 2018). Computer-Supported Collaborative

Learning (CSCL) is an emerging area that leverages technology to facilitate collaborative interactions through scripting and prompting (Schnaubert & Bodemer, 2019).

The rapid technological advancement has driven changes in the education system to ensure younger generations acquire the necessary knowledge and HOTs to meet international educational standards (Ajit et al., 2022). Gamification has emerged as a prominent tool in the learning process, with studies showing its role in enhancing learning motivation and academic performance (Zakaria et al., 2022; Chan & Portuguez, 2021).

Gamification is a versatile approach, applicable across different fields and presented through various resources such as paper, applications, or screens (López, 2019). It combines game elements and design techniques with education to create an enjoyable learning experience, motivating learners to apply their knowledge to real-life problem-solving (Manzano-León et al., 2021). Board games stand out as a prominent gamification method, enhancing motivation, perception, and learning outcomes in the classroom (Lin & Tsai, 2021). Despite the popularity of guessing games and quizzes, there is still a need to develop board games that incorporate typical gamification mechanics (Taspinar et al., 2016). Prior research demonstrates that board games are widely chosen as gamification tools in various subjects and courses, such as physics (Yusoff et al., 2023); chemistry (Alejandria et al., 2023); minerals (Teixeira & Lima, 2023); biology (Ramli et al., 2022); science (Hayati et al., 2022); venomous animals (Diniz et al., 2021); nutrition (Jean, 2021); history (Kesuma et al., 2020); ICT education (Gordon et al., 2020); bioenergy and biofuels (Calero, 2020); statistics (Yaacob, 2019) and multiple subjects like Malay, English, Maths, Science, History, Geography, Civics and Moral (Kassim & Petani, 2019).

Board games have adapted to current electronic and networking advancements and are now accessible on various digital platforms like websites, tablets, and digital tabletop

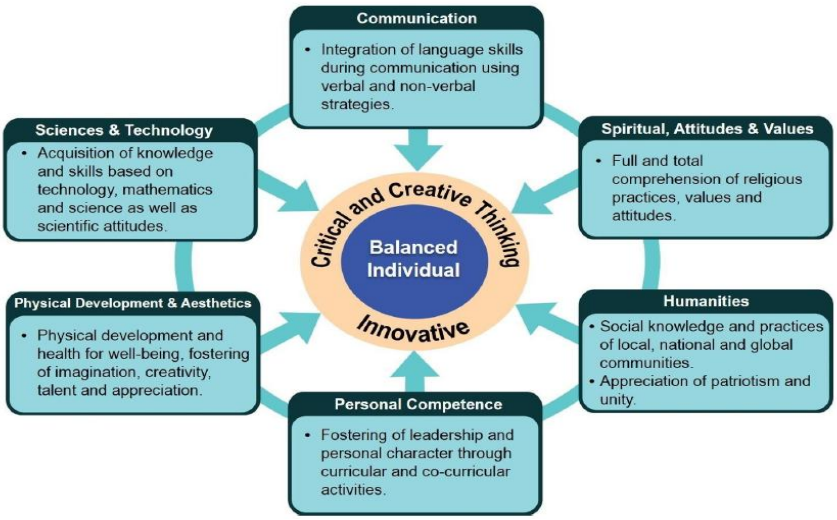
devices (Tan & Mogali, 2021). As teaching methodologies evolve, students encounter new dimensions and techniques of educational games in the classroom. The design and development of Computerized Board Games (CBG) is not new, but recent technological progress opens opportunities for incorporating digital elements, especially in educational fields (Kankainen & Paavilainen, 2019). Ali et al. (2018) suggests that with technology's emergence, well-designed CBG aligned better with students' interests, maintaining learning motivation and facilitating social interaction. Prior research demonstrates that the design and development of digital board games significantly enhance motivation and engagement among learners across various disciplines (Aditya et al., 2021; Liu & Lu, 2021; Pakinee & Puritat, 2021; Tan & Mogali, 2021; Filipe & Victor, 2019; Zou et al., 2019).

1.2 Background of the Study

The Revised Version of the Standard-Based Curriculum was implemented in 2017, replacing the old curriculum for Primary Schools in line with the Malaysia Education Blueprint 2013 – 2025 policy (Talib, 2019). This revision introduced computational thinking in the Science curriculum for Primary One student in 2017, necessitating training for primary teachers on integrating computational thinking into science subjects (Mahmud et al., 2018).

The Science curriculum standards are structured around six strands: Communication, Spiritual, Attitude, Value and Humanity, Personal Development, Physical Development, Aesthetics, and Science and Technology (Figure 1.1). These standards align with the National Philosophy of Education in Malaysia, aiming to equip children with

noble values and foster critical, creative, and innovative thinking and actions (Bahagian Pembangunan Kurikulum, 2017).



***Source**: Curriculum Development Division (2020, pp. 15)*

Figure 1.1: The Framework of Standard-Based Curriculum for Primary School

The Science Year 4 curriculum has three columns for each theme: Content Standard, Learning Standard, and Assessment Standard. These themes, which include Inquiry in Science, Life Science, Physical Science, Material Science, Earth and Space, and Technology and Sustainability of Life, are outlined and promoted in the *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP).

In this context, the second theme of the Year 4 Science curriculum focuses on Human, Animal, and Plant content standards. Under this theme, specific content standards include "Breathing Organs of Animals" and "Vertebrates." Each content standard is further supported by four learning standards, essential for Year 4 pupils to comprehensively understand animals. The standard curriculum for Year 4 Science outlines the performance standards for assessment purposes, incorporating six performance levels with corresponding descriptors for the two content standards under the "Animal" theme, as

depicted in Figure 1.2. This comprehensive approach guides Science teachers to effectively facilitate learning and engagement with their pupils (Markus et al., 2021).

3.0 ANIMAL				
CONTENT STANDARD	**LEARNING STANDARD**	**PERFORMANCE STANDARD**		**REMARKS**
		PERFORMANCE LEVEL	**DESCRIPTOR**	
3.1 Breathing Organs of Animals	Pupils are able to : 3.1.1 Identify the breathing organs of animals. 3.1.2 Classify animals according to their breathing organs. 3.1.3 Make generalisation that some animals have more than one breathing organ. 3.1.4 Explain the observations about the breathing organs of animals through written or verbal forms, sketches or ICT in a creative way.	1	Label the breathing organs of animals.	Notes: Examples of animals' breathing organs: (i) Lungs: cat, bird, crocodile, frog and whale. (ii) Gills: fish, tadpole, crab and prawn. (iii) Moist skin: frog and worm. (iv) Spiracle: cockroach, grasshopper, butterfly and caterpillar.
		2	List the examples of vertebrates and invertebrates.	
		3	Give examples of specific charateristics for each class of vertebrates.	
3.2 Vertebrates	Pupils are able to: 3.2.1 State the meaning of vertebrates and invertebrates. 3.2.2 Give examples of vertebrates and invertebrates. 3.2.3 Classify vertebrates based on specific characteristics for mammals, reptiles, amphibians, birds and fish. 3.2.4 Explain the observations about vertebrates through written or verbal forms, sketches or ICT in a creative way.	4	Classify vertebrates based on their specific charateristics.	Notes: Classes of vertebrates (animals with backbone) consist of mammals, reptiles, amphibians, birds and fish.
		5	Summarise that some animals have more than one breathing organ.	
		6	Communicate creatively and innovatively on the breathing organs of animals and classify vertebrates and their specific charateristics to each class and present the findings.	

***Source**: Curriculum Development Division (2020, pp. 51-52)*

Figure 1.2: Excerpt of a content standard from the primary school standard curriculum (revised) for Year 4 Science.

The Curriculum and Assessment Standard Documents incorporate 21st-century skills as pupils' profiles, particularly emphasising HOTs within the Science classroom. These HOTs elements provide ample opportunities for school teachers to employ various teaching and learning methods and activities, enabling pupils to engage in critical thinking,

discussion, and creative problem-solving (Rabu & Tabli, 2017). The significance of integrating HOTs into Science teaching and learning cannot be underestimated, as it prepares students to compete in the future's Industrial Revolution 4.0 (IR 4.0) (Mahmad et al., 2021).

Mastering HOTs in Science learning poses significant challenges among pupils. Science teachers are responsible for nurturing HOTs in students of all academic levels, given their importance in educational objectives. They must cater to high-achieving and low-achieving pupils, fostering high-level thinking skills for all (Afidah & Retnawati, 2019). Unfortunately, pupils with lower thinking abilities often receive less attention than their high-achieving peers (Mislia et al., 2019). Some teachers resort to drills and practice methods to build knowledge based on existing experiences and provide exercises and guidance in the Science classroom (Rathakrishnan et al., 2018). However, this approach falls short of effectively helping low-achieving pupils master HOTs.

MOE has implemented inquiry-based Science teaching to integrate HOTs in the Science classroom (Ab Hakim & Iksan, 2018). As a strategy for the educational process, inquiry-based Science teaching allows learners to utilize and enhance their HOTs through various inquiry forms, such as question-asking, critical thinking, decision-making, scientific communication, and transfer capability. This approach aims to achieve complex and comprehensive "higher-order" objectives within the classroom (Constantinou et al., 2018) and foster the development of higher-order thinking skills among pupils (Scheiller, 2021).

CL is a prominent teaching method in inquiry-based approaches (Korkman & Metin, 2021), facilitating communication and socialisation among pupils during science learning. However, certain challenges have been identified when implementing CL in the

Science classroom, such as pupils' hesitance to ask questions due to the lesson structure and teachers' limited experience creating challenging tasks (Saito, 2021). Consequently, some Science teachers resort to Conventional Teaching (CT) methods, considering CL time-consuming (Appavoo et al., 2019), feeling less confident in conducting CL (Arta, 2018), and experiencing stress when adopting new teaching methods with educational technology (Fernández-Batanero, 2021). Nonetheless, the need for change in current teaching practices is evident, as conventional classroom activities have not adequately prepared learners with high-order thinking skills to meet the challenges of the IR 4.0 era (Qureshi et al., 2021).

School teachers should prioritize motivational factors when selecting tools to enhance Science learning effectiveness (Tan et al., 2018). One of the current teaching methods in science education is gamification technology (Alahmari et al., 2023; Sum, 2023; Belova, 2021; Vargas et al., 2020; Hursen & Bas, 2019). Various gamification elements have been introduced to facilitate Science learning for students, including gaming elements and aesthetics that enhance their motivation to learn (López Carrillo et al., 2019; Zimmerling et al., 2019). Examples of these elements include Quizizz (Handoko et al., 2021; Razali et al., 2020), interactive games and learning (Halamy et al., 2022; Sumandal, 2022; Sari et al., 2019; Misbah et al., 2019; Sun & Hsieh, 2018), computer-based games (Lufti & Hidayah, 2021), and board games (Kesuma et al., 2020; Gordon et al., 2020; Martín-Lara & Calero, 2020; Yaacob, 2019). Board games, played by two, three, or four persons at a table, have gradually been introduced in schools as a more engaging and enjoyable learning method.

A lack of board games related to science subjects in Malaysia has been identified (Chen et al., 2021; Kibala, 2018). Additionally, there is currently no indication of CBG

with CL being used in the educational field in Malaysia. As a result, a research gap requires attention to address this issue, specifically by exploring the development of CBG with CL for primary school pupils in Science learning. This research should focus on the impact of CBG with CL on students' academic performances, learning motivation, and social interaction in the classroom.

This research utilized the Asian Student Attitudes towards Science Class (ASATSC) as secondary data developed by Wang and Berlin (2010) to support the research's problem statements. The survey instrument comprised two main sections. The first section gathered demographic information on school pupils' genders and class levels. The second section consisted of 30 items with three constructs: 13 items for Science Enjoyment (SE), eight items for Science Confidence (SC), and nine items for Importance of Science (IS). Participants responded to these items using a five-point Likert Type scale (1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree). The collected data and feedback from Year 4 pupils in the research school were then compared to previous research.

ASATSC has been utilized to collect the secondary data regarding to the responses from Year 4 pupils who study in one of the national-type Chinese primary schools, Sibu. Based on the findings from ASATSC survey conducted among Year 4 pupils at the selected National-Type Chinese Primary School, the pupils felt apprehensive about answering questions in Science class and found experiments challenging. Pupils' confidence in responding to questions increased when they were allowed to familiarize themselves with the question format before the assessment. Feedback from pupils indicated that Science textbook materials were not helpful for their learning and rarely provided knowledge applicable to their daily lives. Pupils expressed a preference for teachers who

used interactive methods like field trips rather than the traditional 'Talk and Chalk' approach. Pupils found Science class uninteresting, including the experiments, indicating a potential lack of engagement with the subject matter. Also, pupils found watching Science films on TV boring and did not find the questions in the Science workbook useful for their learning. While pupils were interested in group-based learning experiences, they mentioned that field trips did not significantly contribute to effective Science learning.

1.3 Problem Statements

Science is central to the primary school curriculum, requiring all pupils to learn in the classroom (Diyana et al., 2018). The primary goal of science education at this level is to equip pupils with essential skills, knowledge, and values. They must acquire proficiency in scientific skills and understanding of the world, as emphasised in STEM education, to meet the demands of the STEM industry (Razali et al., 2020) and face future international challenges and competitions such as Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA). However, there is controversy surrounding Malaysia's education system, as recent TIMSS and PISA assessments indicate a noticeable decline in rankings (Aliyu, 2020; Suhaili et al., 2020). Malaysia ranked 49 out of 79 countries, scoring 438 in Science in the latest 2018 ranking (Mat & Zakaria, 2021).

Alhadabi (2021) highlighted that pupils with good academic achievements are highly interested in the subject. However, their motivation primarily focuses on attaining good examination results rather than mastering scientific skills (Phang et al., 2020). This situation arises because students are frequently exposed to question-based formats without

sufficient emphasis on understanding the subject matter. Consequently, they struggle to answer questions that assess HOTs, impacting their 21st-century skills, mastery, and self-confidence (Mat & Yusoff, 2019; Leak et al., 2018). Evaluating Science's learning and teaching processes are essential, and attitudes towards science can serve as a measurement (Kurniawan et al., 2019). When the ASATSC survey was administered to Year 4 pupils at a National-Type Chinese Primary School, it revealed that they felt apprehensive about answering questions in science class, finding experiments challenging. Their confidence in responding to questions increased when they were allowed to familiarize themselves with the question format before the assessment (Morgan & Chen, 2021).

A noticeable difference was observed in the standard of questions between examinations or assessments for Level 1 (Years 1 to 3) and Level 2 (Years 4 to 6). Based on the feedback from ASATSC, Year 4 pupils in Level 2 struggled to achieve good scores in science class, finding the questions in the Science workbook challenging (Stefanidou et al., 2019). The Science examination papers or assessments comprised open-ended structure questions with HOTs elements, making them more difficult to answer. Many Year 4 pupils faced difficulties answering these questions effectively, resulting in lower scores than their academic performances in Level 1. This discrepancy is attributed to the nature of the questions, with low-level questions requiring simple recall of information, while high-level questions demand the application or extension of taught ideas (Kaya & Temiz, 2018).

The pupils' lack of understanding of specific Science concepts contributes to low academic performance in the classroom (Fowler, 2018). Their Science learning remains superficial and lacks depth, with their preconceptions not adequately addressed (Bianchi et al., 2021). Many pupils encounter difficulties due to unfamiliar and foreign terminology in Science learning (Darling-Hammond et al., 2020). According to feedback from Year 4

pupils in ASATSC, the Science textbook materials were not helpful for their learning and rarely provided knowledge applicable to their daily lives (Zulfah & Aznam, 2018). This situation is linked to their struggles in comprehending scientific terminologies (Soeharto & Csapó, 2019), resulting in poor performance in examinations or assessments.

According to Bayuni et al. (2018), emphasising basic concepts in Science learning at the primary school level is crucial as it helps pupils develop higher-level thinking and complexity in the future. However, pupils may unintentionally create and reinforce misconceptions if they fail to connect new information with their existing knowledge (Kurtuluş & Tatar, 2021). Prolonged misconceptions concern Science teachers, particularly for Level 2 pupils exposed to abstract concepts, such as those in natural Sciences, which they find challenging to understand (Laeli, 2020). Many pupils have expressed that the materials in the Science textbook are difficult to comprehend, making it challenging to grasp what is taught in Science class. Consequently, they are more likely to face misconceptions during Science learning in Level 2 than in Level 1.

Certainly, Science holds a prominent position as one of the core subjects in the primary school curriculum, with all pupils required to learn it in the classroom. The primary goal of Science education at this level is to facilitate experiential learning, enabling pupils to acquire essential skills, knowledge, and values while developing their scientific skills and understanding of the world. However, a significant observation has been made regarding the Bachelor of Science Education (Primary) program offered by the Institute of Teacher Education, which covers more generalised Science content (Mahmud et al., 2018). Consequently, some Science teachers possess limited content knowledge, potentially impacting pupils' comprehension and hindering the successful implementation

of inquiry-based Science teaching within the Standard-Based Curriculum for Primary schools.

In Malaysia, despite the implementation of student-centred teaching approaches, school teachers still dominate their Science classrooms (Saleh & Liew, 2018). They can choose teaching methods, but many still adhere to conventional approaches, such as the chalk-and-talk method, leading to one-way communication and emphasising memorisation (Mat et al., 2022; Shah et al., 2017). Feedback from ASATSC revealed that Year 4 pupils preferred teachers who used interactive methods like field trips rather than the traditional 'Talk and Chalk' approach (Garraway-Lashley, 2019). They found lectures in Science class uninteresting, indicating that many Science teachers rely on textbooks and PowerPoint slides during lessons. Consequently, social interaction among pupils in the Science classroom is limited, despite the emphasis on inquiry-based learning and CL as one of the preferred methods by MOE (Korkman & Metin, 2021).

Science teachers often prioritize completing the Science syllabus to ensure their pupils are prepared for school assessments, leading to neglecting the Science classroom learning process and the inability to achieve learning objectives (Abdullah et al., 2017; Ramli & Talib, 2017). Currently, teachers place more emphasis on examinations and assessments, disregarding the development of a strong understanding and concept of learning in pupils, such as real-world problem-solving, critical thinking, and Science process skills (Chin et al., 2019). They tend to use drills to train pupils solely for answering exam questions, resulting in poor performance in Science subjects, especially when faced with HOTs questions. Feedback from Year 4 pupils in the ASATSC indicated that they found Science class uninteresting, including the experiments, suggesting that teachers might focus on repetitive practice rather than engaging and interactive teaching methods

(Huang et al., 2020). Consequently, Science teachers neglect CL and discourage social interaction among pupils (Saito, 2021; Appavoo et al., 2019; Arta, 2018).

The motivation for learning Science is crucial for school pupils as it influences their future career choices in the STEM field (Duschl, 2019). High motivation in Science also allows students to develop a sustained interest in STEM careers (McFadden & Roehrig, 2020). Pupils' learning motivation in Science becomes more meaningful when they recognise its relevance in everyday life, encouraging active participation in the classroom (Spandana et al., 2020). Previous studies have consistently highlighted the importance of learning motivation in academic achievements in Science subjects (Caymaz & Aydin, 2021; Fortus & Touitou, 2021; Teppo et al., 2021; Nja et al., 2020; Steinmayr et al., 2019; Bal-Tastan, 2018). Pupils motivated to learn Science perceive its usefulness in future careers and acknowledge its significance in health, life, and their understanding of the world (Haw, 2021).

Several studies have reported findings indicating that school pupils exhibit lower levels of learning motivation in Science, which subsequently result in lower performance in the classroom (Aque et al., 2021; Bulić & Blazevic, 2020; Spandana et al., 2020; Triyanto & Handayani, 2018; Mahanti & Sarkar, 2018). The feedback obtained from ASATSC revealed that a significant number of Year 4 pupils found watching Science films on TV boring (Castro et al., 2021), disliked reading Science posters (Siswoyo et al., 2020), only occasionally looked forward to Science class (Wigfield & Eccles, 2020), did not enjoy Science class (Phang et al., 2020), did not find the Science textbook interesting to read (Park et al., 2020), would prefer school without Science class (Juuti et al., 2021), and disliked answering questions in the Science workbook (Logan, 2023. Consequently, their low motivation during Science learning in the classroom contributed to their below-

average performance in school assessments, further supporting the connection between low motivation and academic performance.

Gamification is considered the most suitable teaching and learning method for the current educational landscape, as it incorporates game mechanics into non-game environments and various tools or software (Zainuddin et al., 2020). This approach promotes active student participation, shifting away from the traditional teacher-centred approach, and motivates students to stay engaged during their studies. Gamification has been found to increase learning motivation (Navarro-Espinosa et al., 2022) and generate interest in learning among school pupils (Lim & Yunus, 2021). Moreover, it is regarded as one of the most effective strategies for enhancing pupil engagement (Göksün & Gürsoy, 2019; Hanafiah et al., 2019), boosting their motivation to teach (Rodrigues et al., 2019), improving academic achievement (Yildirim, 2017), and reducing distractions while enhancing the learning curve (Kayimbasioglu et al., 2016). Notably, the integration of gamification, particularly through smartphone apps and games (Ishaq et al., 2019), in Science education has garnered significant interest, as it resonates with students' familiarity and captures their attention (Loganathan et al., 2019).

The gradual adoption of technology in recent years has led to the recognition that the gamification approach is a viable solution, especially as teaching in the 21st century becomes increasingly challenging (Ishak & Hussain, 2020). Teachers face challenges consistently, including implementing student-centred learning, fostering HOTs among students, and addressing low learning motivation (Kasim & Abdurajak, 2018). While gamification has generally been considered successful in engaging learners (Molnar, 2018) and has positively impacted achievement, its influence on learning outcomes has been scrutinised (Kalogiannakis et al., 2021). While gamification techniques may succeed in

capturing students' attention and motivating them to participate actively in learning activities, there is a question of whether these activities truly enhance learning outcomes in terms of knowledge acquisition, retention, and transfer (Sailer & Homner, 2020). Critics argue that students may become more focused on achieving game-related rewards or progressing through levels rather than mastering the underlying content or skills (Jusas et al., 2022). This emphasises the need for teachers to consider motivational factors that contribute to academic achievement when selecting teaching tools to enhance learning effectiveness (Tan et al., 2018).

The introduction of CBG to school pupils is worth considering, as it incorporates technology and gaming elements, which are increasingly relevant in their lives (Loganathan et al., 2019). While using board games in teaching and learning activities is widespread, digital board games are not extensively utilized (Khoushaini et al., 2022). Educational emphasis is placed on digital games and mobile apps, but they often lack collaborative elements, with teachers primarily using interactive media (Hillmayr et al., 2020), video games (Yunus et al., 2021), quizzes (Handoko et al., 2021; Razali et al., 2020) to facilitate learning in the classroom. Feedback from Year 4 pupils in ASATSC revealed that the questions in the Science workbook did not aid their learning, and they did not find the Science experiments particularly useful (Sánchez-Martín et al., 2020). Although digital games have advantages in improving understanding of certain topics, they mainly focus on individual learning at the pupils' own pace, overlooking the elements of learning motivation and social interaction (Darling-Hammond et al., 2020). Consequently, this approach falls short of meeting the requirements of inquiry-based Science learning, especially CL.

Undoubtedly, finding a single tool that perfectly meets all learners' needs is a challenging task. Therefore, utilizing digital games as a supplementary tool for learning appears to be a viable alternative (Sanmugam et al., 2021). However, it should be acknowledged that developing a comprehensive game for specific subjects or subtopics, especially in the digital format, may be beyond the capabilities of educators. Although game generators are now readily available and have the potential to stimulate higher-order thinking among pupils, they have not yet been extensively used to teach the intended topics (Meishar-Tal & Kesler, 2021).

The availability of Paper-Based Board Games (PBBG) for primary Science learning in Malaysia is limited, and most recent research has focused on other subjects and fields in different countries. These studies have explored various topics, such as marine environment and ocean awareness in Spain (Arboleya-García & Millarus, 2022), pre-service teachers' experiences in South Africa (Botes, 2022), physics in Poland (Dziob, 2020), K-12 Science in the United States (Quintana et al., 2020), cognitive skills in Turkey (Türkoğlu, 2019), physics and astronomy in Ireland (Cardinot & Fairfield, 2019), language, culture, and history learning in Poland (Lodzikowski & Jekiel, 2019), mathematical learning in the United States (Hendrix et al., 2018), health and medicine-related topics in Brazil (Olympio & Alvin, 2018), electric circuits in the United States (Kibala, 2018), labor-monitoring skills in Kenya, Malawi, and Tanzania (Lavender et al., 2019), chemistry and engineering in Brazil (Triboni & Weber, 2018), bullying in Taiwan (Nieh & Wu, 2018), and English language in the United States (Cheng, 2018). According to the ASATSC survey, Year 4 pupils in Malaysia mentioned that field trips did not significantly contribute to effective Science learning but were interested in group-based learning experiences (Klippel et al., 2020). The lack of experience playing non-digital

board games, especially PBBG in Science learning, led the researcher to design and develop PBBG for three Science topics in the Year 4 syllabus for this research.

In Malaysia, there have been several recent studies on digital board games in different fields, but none specifically focused on Science learning in primary school. These studies explored topics such as complex medical subjects (Tan & Mogali, 2021), elementary Science (Premthaisong & Srisawasdi, 2020), health and physical education (Zheng et al., 2018), and vocabulary learning in language education (Ali et al., 2018). After providing feedback through ASATSC, Year 4 pupils expressed that they considered Science class a waste of time and felt that watching Science films on TV did not contribute to effective Science learning (Howell, 2021). Hence, PBBG and CBG could be promising educational tools for Science learning in this research.

This research was believed to offer numerous advantages in addressing these problems: implementing a student-centred and material-centred approach instead of relying on CT methods (Ghaizi et al., 2022); enabling pupils to engage with questions involving HOTs (Hamzah et al., 2022); boosting motivation and academic performance in Science learning (Tong et al., 2022); reducing misconceptions (Moodley & Gaigher, 2019); improving understanding of scientific terminologies and overall performance; fostering CL (Ramirez, 2021); introducing pupils to non-digital board games and promoting Science learning (Silveira, 2020); and effectively utilizing classroom time through the application of PBBG and CBG.

This research's crucial and primary objectives were to enhance pupils' academic performances and investigate the impact of learning motivation and social interaction in Science learning. The study sought to present an innovative approach for Science teachers

working with 10-year-old participants, focusing on three distinct teaching methods: CT, PBBG and CBG with CL.

1.4 Research Objectives

This research examined the effectiveness of CT, PBBG and CBG, with CL for Science learning among 10-year-old participants in the classroom. This research is designed to achieve the specific research objectives:

1) To design PBBG and CBG specifically tailored for 10-year-old participants' Science learning.

2) To develop PBBG and CBG that effectively support and enhance the Science learning experience of 10-year-old participants.

3) To compare the gender differences between CT, PBBG and CBG in learning Science among 10-year-old participants

4) To compare the differences in pre-test and post-test scores between CT, PBBG and CBG in learning Science among 10-year-old participants.

5) To analyze the differences in social interaction between CT, PBBG and CBG in learning Science among 10-year-old participants.

6) To analyse the differences in learning motivation between CT, PBBG and CBG in learning Science among 10-year-old participants.

1.5 Research Questions

This research answered the following research questions.

1) What were the design features of PBBG and CBG specifically tailored for 10-year-old participants' Science learning?
2) How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
3) How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
4) How does social interaction differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
5) How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

1.6 Research Hypotheses

A control group (CT) and two experimental groups (PBBG and CBG) had pre-test and post-test data. Hence, null hypotheses (H_o) and alternative hypotheses (H_a) were written for each group.

H_{o1}: There is no significant difference in gender factors between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{a1}: There is a significant difference in gender factors between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o2}: There is no significant difference in the change scores (pre-test to post-test) between the controls group (CT) and the two experimental groups (PBBG and CBG).

H_{a2}: There is a significant difference in the change scores (pre-test to post-test) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o3}: There is no significant difference in the mean scores (social interaction) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a3}: There is a significant difference in the mean scores (social interaction) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o4}: There is no significant difference in the mean scores (self-challenge dimension of learning motivation) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a4}: There is a significant difference in the mean scores (self-challenge dimension of learning motivation) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o5}: There is no significant difference in the mean scores (self-confidence dimension of learning motivation) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a5}: There is a significant difference in the mean scores (self-confidence dimension of learning motivation) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o6}: There is no significant difference in the mean scores (assessment dimension of learning motivation) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a6}: There is a significant difference in the mean scores (assessment dimension of learning motivation) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o7}: There is no significant difference in the mean scores (learning motivation dimension) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a7}: There is a significant difference in the mean scores (learning motivation dimension) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

H_{o8}: There is no significant difference in the mean scores (learning motivation) between the control group (CT) and the two experimental groups (PBBG and CBG).

H_{a8}: There is a significant difference in the mean scores (learning motivation) between at least one pair of groups (e.g. CT vs. PBBG, CT vs. CBG, or PBBG vs. CBG).

1.7 Significance of the Research

This research aimed to identify and address learning problems and difficulties faced by 10-year-old participants in understanding Science concepts in the classroom. It explored using CT, CL with PBBG, and CBG to provide effective solutions. The findings and insights from this research offer valuable guidance to teachers and contribute to improving Science teaching and learning activities, making them more efficient and accessible. Additionally, the application of CBG showed potential for implementation in other subjects. Through CL, 10-year-old participants were empowered to explore and utilize information independently, enhancing their comprehension of specific topics and concepts and improving academic achievement in their examinations.

This research contributes to the theoretical understanding of learning difficulties faced by 10-year-old students in comprehending Science concepts. By identifying and addressing these challenges, the research enhances the knowledge base regarding cognitive development and learning processes at this age. Also, it explores the effectiveness of various teaching strategies, including CT, PBBG, and CBG with CL, in addressing learning difficulties. This exploration adds to the theoretical framework of educational psychology by examining innovative approaches to teaching and learning.

The findings and insights from this research offer valuable guidance to teachers in designing and implementing effective instructional strategies in Science classrooms. By understanding the specific challenges faced by students and the effectiveness of different teaching methods, educators can tailor their approaches to better meet the needs of their students. It contributes to the improvement of Science teaching practices by providing evidence-based recommendations for enhancing teaching and learning activities. By incorporating CT, CL with PBBG, and CBG into their instructional practices, teachers can make Science education more engaging, efficient, and accessible for students. The application of PBBG and CBG demonstrate potential for implementation in other subjects beyond Science. This expands the practical implications of the research, as the effective teaching strategies identified can be adapted and applied across different academic domains to improve student learning outcomes. Through PBBG and CBG with CL, this research empowers 10-year-old participants to explore and utilize information independently, thereby enhancing their comprehension of specific topics and concepts. This not only improves academic achievement in Science examinations but also fosters critical thinking skills and self-directed learning abilities that are valuable across various subjects and contexts.

Furthermore, this research provides valuable insights for pupils and teachers in National-Type Chinese Primary Schools to explore creative approaches that make learning new concepts easier. Science teachers are encouraged to develop innovative ideas for teaching new concepts using PBBG and CBG by emphasising the utilisation of learners' strengths and unique learning styles. This approach fosters a creative and critical thinking environment, leading to a more effective, meaningful, and engaging teaching and learning process with PBBG and CBG.

This research highlights the effectiveness of creative approaches, such as PBBG and CBG with CL, in making learning new concepts easier for pupils. Educational policymakers can consider integrating these innovative teaching methods into the curriculum to promote active learning and enhance student engagement across different subjects. The findings suggest that Science teachers should be encouraged to develop innovative teaching ideas using PBBG and CBG to cater to pupils' diverse learning needs and styles. Policymakers can allocate resources for teacher training programs and workshops focused on incorporating these creative teaching strategies into classroom practices, ensuring that educators are equipped with the necessary skills and knowledge to effectively implement them. This research underscores the importance of fostering a creative and critical thinking environment in classrooms. Policymakers can emphasize the integration of PBBG and CBG as tools to promote active learning, problem-solving skills, and collaborative learning among pupils. Educational policies can incentivize schools to adopt these approaches and provide support for implementing them effectively. By emphasizing the utilization of learners' strengths and unique learning styles, the research advocates for a student-cantered approach to teaching and learning. Policymakers can advocate for policies that promote personalized learning experiences tailored to individual

pupils' needs, preferences, and abilities, fostering a more inclusive and supportive learning environment in National-Type Chinese Primary Schools.

1.8 Definitions of Terms

In this research, the definitions of the terms used in operation were as follows:

1.8.1 Science Classroom

A Science classroom is a dynamic learning environment where Science teaching utilizes communication tools (Kubat & Dedebali, 2018). It is also redefined as a communicative practice, emphasising effective communication during school Science lessons using the communicative approach framework (Metcalfe, 2019) (Jensen & Gerber., 2020). In this context, the scientific practice involves the active participation of pupils in constructing their ideas (Jimenez-Liso et al., 2021), and the Science classroom serves as a reflection of the educational practice for simultaneous learning and development (Darling-Hammond et al., 2020).

The Science classroom for this research refers to a physical or virtual learning environment specifically designed for Science instruction. It includes instructional materials, such as PowerPoint Slides, PBBG and CBG aimed at facilitating the teaching and learning of Science concepts from Year 4 syllabus at National-type Chinese Primary Schools, Sibu. It promotes inquiry-based learning, problem-solving, and critical thinking, allowing 10-year-old participants to explore scientific concepts through CT, PBBG and CBG with CL.

1.8.2 Pupils

In this research, "pupils" were defined as individuals or learners enrolled in National-Type Chinese Primary Schools in Sibu, Sarawak, who were 10-year-old participants. They were under the direct supervision of teachers and were eligible to participate in both the experimental and control groups. Pupils exhibited diverse attitudes towards teaching and learning Science (Kharuddin et al., 2021; Nugraha et al., 2020) and responded differently to specific classroom environments in modern times (Yilmaz, 2017). They demonstrated varied learning styles, with preferences for different types of information and approaches to processing perceived information, mainly through questioning techniques in the Science classroom (Rahayu et al., 2019).

For the purpose of this research, "pupils" are operationally defined as individuals or learners who are enrolled in National-Type Chinese Primary Schools located in Sibu, Sarawak, Malaysia. These pupils are specifically identified as 10-year-old participants, indicating their age at the time of the research. The term "10-year-old participants" operationally refers to pupils who are approximately 10 years old at the time of data collection or participation in the research. This age group typically corresponds to pupils in Year 4 of primary education, as primary schooling in Malaysia typically starts at age 7.

1.8.3 Collaborative Learning (CL)

CL shows great potential in improving pupils' learning performance, as it fosters interaction among them in the classroom (Khan et al., 2021). This flexible and adaptable approach applies to various disciplines, including Science subjects in contemporary

schools. CL encompasses a range of educational approaches that involve the intellectual engagement of pupils, either individually or through collaboration with teachers.

In CL settings, pupils typically collaborate in groups of two or more to explore and understand the skills required in the Science classroom (Azhar et al., 2022). CL activities vary widely, but the key element is providing pupils with opportunities to interact during games, which has been shown to enhance their learning performance (Huang et al., 2020). By engaging in collaborative problem-solving and discussions, pupils can deepen their understanding and develop critical thinking skills, leading to improved learning outcomes.

CL represents a significant departure from the traditional teacher-centred approach in schools. While teacher lectures may still be present, they are complemented by pupils' active discussions and diligent engagement with the learning materials (Ariffin, 2021). In CL, teachers act as expert facilitators who guide students in constructing their understanding of Science through scaffolding (Rahma et al., 2020). This approach empowers pupils to actively participate in their learning, encouraging critical thinking and fostering a deeper grasp of scientific concepts through meaningful interactions and problem-solving activities.

For this research, CL refers to an instructional approach where 10-year-old participants from National-Type Chinese Primary Schools work together in groups to achieve common learning goals. It involves collaborative interactions among participants, where they actively engage in shared tasks, discussions, and problem-solving activities to enhance their understanding of subject matter and develop their cognitive and social skills through the implementation of PBBG and CBG.

1.8.4 Conventional Teaching Approach (CT)

The CT approach primarily relies on teacher-directed techniques, where pupils passively sit and listen to their teachers' concepts using the 'Talk and Chalk' method in the classroom (Tularam, 2018). Educational institutions follow a one-way flow of information, with teachers being the sole source of knowledge, and pupils are expected to take notes and memorise the content (Muganga & Ssenkusu, 2019). In this approach, teachers have full control over the learning experience, and the pupils have limited opportunities to interact with their classmates (Serin, 2018). Various activities such as modelling and worked samples (Lak et al., 2017), presentations (Shah & Kumar, 2020), structured laboratory experiments (Shana & Abulibdeh, 2020), lectures (Murphy et al., 2021), and knowledge transmission (Kaymakamoğlu, 2018) are commonly associated with the CT approach. However, this method has been proven to be monotonous and results in negative attitudes toward Science learning in contemporary times (Musalamani et al., 2021).

In this research, the PowerPoint presentation refers to a digital slideshow created using Microsoft PowerPoint in Science classroom. The presentation typically consists of a series of slides containing text, images, graphics, and multimedia elements, such as audio or video clips from three selected science topics, such as “Properties of Light”, “Energy” and “Materials”. Hence, CT, also knowns as traditional or lecture-based teaching, is a teaching approach where the researcher delivers information to the 10-year-old participants of National-Type Chinese Primary Schools through PowerPoint presentations.

1.8.5 Computerized Board Games (CBG)

CBGs are educational games designed to transform pupils' knowledge and foster their interest in learning (Ali et al., 2018). In this research, board games refer to games presented in a computer or mobile learning environment within the Science classroom. CBG encompass an agreed set of components, including the game board, pieces, markers, and money, accompanied by an agreed set of rules (Kankainen & Paavilainen, 2019). The dynamic nature of CBG ensures that each play-through offers different and unpredictable content. Moreover, CBG can incorporate digital elements, necessitating electronic devices such as computers or tablets. In the context of contemporary primary school Science syllabuses, CBG can effectively meet specific criteria applicable to all types of games, contributing to enhanced learning experiences in the classroom. For this research, CBG are specifically designed to facilitate learning and engagement with science concepts among 10-year-old participants in the classroom setting.

1.8.6 Paper-Based Board Games (PBBG)

PBBG are physical versions of board games played on a table, typically involving two, three, or four individuals (Sousa & Bernardo, 2019). These games consist of rules, a physical playing surface, and tokens, enabling players to interact with each other while observing the playing area simultaneously (Barbara, 2017). PBBGs are designed to be played on a table in one sitting, with all the necessary physical pieces placed in a cardboard box (Pierce et al., 2018). These games follow a stable set of rules that dictate the number of pieces on the board, the positions for these pieces, and the possible moves players can make (Bayeck, 2020). Additionally, PBBG allows for physical and tactile interactions with

other players and game elements, such as dice, cards, and board pieces (Nilsen et al., 2018; Wasserman & Banks, 2017). They encompass conceptual components like rules, rewards, and the scope of competition, as well as social components, including interactions among players, live feedback, and physical cues. PBBG emphasise players as individual first, fostering face-to-face game play in a social setting (Rogerson & Gibbs, 2018). Over time, PBBG has gradually been introduced in schools as a more engaging and enjoyable learning method.

The participants in this research refer to 10-year-old students enrolled in a National-Type Chinese Primary School in Sibu, Sarawak, specifically those involved in the experimental groups utilizing PBBG for learning science concepts, specifically "Properties of Light", "Energy" and "Materials". The total number of participants included 204 participants who were randomly assigned to PBBG groups.

1.8.7 Learning Motivation

Motivation plays a crucial role in Science learning, as it enhances pupils' engagement and drives them toward achieving their goals (Wahono et al., 2020; Haw, 2021). It is a complex, multidimensional construct that interacts with cognition to influence pupils' learning experiences (Korhonen et al., 2019). Learning motivation encompasses guidance, impulses, and internal emotions or desires that propel action (Membiela et al., 2022; Wood, 2019). As a vital aspect of education, learning motivation is a means to initiate and sustain learning behaviours, constituting a prerequisite for meaningful learning among pupils (Fortus & Touitou, 2021; Jasna & Natalija, 2022). Through learning motivation, pupils exhibit a drive and belief in achieving success in the Science learning

process (Iwuanyanwu, 2019). In the context of primary school pupils, learning motivation can be categorised into two types: external and internal motivation (Prokopchuk et al., 2020). The pupils' motivation toward Science learning significantly impacts their Science achievement (Chai et al., 2021).

In this research, learning motivation among 10-year-old participants from National-Type Chinese Primary Schools was assessed based on their level of interest, enthusiasm, and willingness to participate in science learning through PBBG and CBG with CL activities. It encompasses intrinsic motivation (e.g., curiosity, enjoyment) and extrinsic motivation (e.g., rewards, recognition), aiming to understand the differences in motivation across the CT, PBBG, and CBG approaches.

1.8.8 Social Interaction

Social interaction refers to two or more individuals engaging and behaving towards each other in various ways (Ellwood & Abrams, 2018). It involves the interplay between different personalities, groups, or social systems, mutually influencing one another and leading to cause-and-effect relationships and close interdependence (Lagat & Concepcion, 2022; Ritonga & Sibuea, 2019). In the classroom context, social interaction is facilitated through CL (Ghavifekr, 2020), allowing teachers to cater to their pupils' learning needs effectively. Through social interaction, pupils engage with their peers and teachers, acquiring information and enhancing the Science teaching and learning process (Rizkia et al., 2021). In the context of learning science among 10-year-old participants from National-Type Chinese Primary Schools, social interaction encompasses peer-to-peer

interactions, collaborative problem-solving, sharing of ideas, and group discussions during instructional activities.

1.9 Summary

This chapter comprehensively covered various aspects of the research. It commenced with an introduction and provided essential background information. The problem statements, research objectives, research questions, and the research's significance were presented, along with clear definitions of the variables used. The subsequent chapter explored relevant literature, primarily focusing on Malaysia Education Blueprint 2013 - 2015, particularly on STEM education and the revised version of Standard-Based Primary Schools. Moreover, it examined diverse teaching and learning approaches in Science education, encompassing inquiry-based Science learning, CT, and CSCL, which employed CL to foster social interaction among pupils.

Additionally, Chapter 2 provided valuable insights into gamification methods in education, with a special focus on board games and their components. It thoroughly detailed the design and development process of both PBBG and CBG, effectively incorporating CL principles. Furthermore, the chapter extensively explored pupils' learning motivation in the context of Science learning, specifically concerning board games. Lastly, Chapter 2 elaborated on Activity Theory (AT) and Social Constructivism Theory (SCT), serving as the research's relevant theoretical framework.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This chapter aimed to enhance the 10-year-old participants' academic performance, social interaction, and learning motivation in the Science classrooms of National-Type for Chinese Primary Schools. To achieve this, a literature review was conducted on digital and non-digital educational board games, social interaction, and learning motivation. The chapter begins with an overview of the current trends in Science education in Malaysia, focusing on Standard-Based Primary Schools and Science classrooms. Teaching and learning approaches, such as inquiry-based Science learning and CSCL, were discussed briefly, emphasizing CT and CL in primary Science education as they influence social interaction among pupils. The chapter specifically focuses on educational board games as a gamification method, detailing their components, design, and development in education. The utilization and potential importance of PBBG and CBG in CL in Science were explored, as they were underrepresented in previous literature. The literature also supports the impact of board games on learning motivation in Science, irrespective of whether the motivation is intrinsic or extrinsic among pupils from National-Type Chinese Primary Schools. Additionally, this research uses AT and SCT to support the theoretical framework.

2.2 Malaysia Education Blueprint 2013 – 2025

Education undoubtedly holds a pivotal role in shaping the capabilities of the new generation to confront significant global changes (Rusdin & Ali, 2019). In tandem with the demands of 21st-century modernization (Assalihee & Boonsuk, 2023), Malaysia's education system has been gradually transforming. As part of this transformation, MOE has meticulously devised new secondary and primary school curricula encompassing Science subjects. The Malaysian Education Blueprint 2013-2025, ushered in by the MOE, is a testament to the government's unwavering commitment to effect transformative changes in the national education framework (Osman & Yaakub, 2021). This resolve has prompted a comprehension revision of curricula across secondary and primary schools have been revised. Consequently, the Standard-Based Curriculum for Secondary School and the Standard-Based Curriculum for Primary School were inaugurated in 2017. These revisions underscore the nation's resolute endeavour to elevate the educational landscape and enrich students' learning experiences of students at all levels.

Within Science education, two significant shifts aimed at fulfilling the five fundamental aspirations of the Malaysian Education System: Access, Quality, Equity, Unity, and Efficiency (Bakar, 2023). These shifts revolved around "providing equal access to quality education of an international standard" (Shift 1) and "transforming teaching into the profession of choice" (Shift 4). A policy has been enacted to "benchmark the learning of Mathematics and Science to the international standards" to accomplish Shift 1. Consequently, a comprehensive review of the education system, encompassing Science subjects, has been undertaken since the inception of the Standard-Based Curriculum for Primary Schools in 2017, extending through to the present (Sulaiman et al., 2021). Another pertinent policy to Science education is "strengthening STEM education quality." This

multifaceted approach demonstrates Malaysia’s proactive commitment to fostering a robust and progressive education system' in tandem with the evolving global landscape.

2.2.1 STEM Education

STEM education has emerged as a prominent global initiative, influencing economic, political, and educational policies (Ravana & Palpanadan, 2022). Adopting STEM education aims to enhance learners' STEM skills and competencies across all educational tiers, from kindergarten to higher education. This emphasis on STEM education is paramount in ensuring a consistent and high-calibre stream of skilled professionals and experts for the STEM industry, contributing to economic growth. This role becomes especially pivotal in the Fourth Industrial Revolution (IR 4.0) (Khotimah et al., 2021).

IR 4.0 encapsulates physical cyber, the Internet of Things (IoT), knowledge, innovation, and human capital in today’s modern world (Philbeck & Davis, 2018). Meeting these criteria is instrumental for Malaysia's progress towards achieving developed nation status (Mustafa et al., 2022). As a pedagogical approach, STEM education integrates the foundational disciplines of Science, technology, engineering design process, and mathematics (Lok & Hamzah, 2021). The crux of STEM education’s significance lies in forging explicit connections between these disciplines and their applicability to real-world challenges posed by IR 4.0 (Afful et al., 2020).

Notably, Science occupies a pivotal role within STEM education. As a testament to this importance, MOE has designated it as a compulsory subject for primary school pupils in Malaysia, irrespective of the school type and medium of instruction (Mahmud et al.,

2018). Furthermore, Science remains a compulsory subject for lower and upper-secondary level students who opt not to pursue pure science classes in Malaysian secondary schools. This decision underscores the vital role of Science education in fostering a robust foundation of scientific knowledge and competencies among students across diverse educational levels.

2.2.2 Revised Version of Standard-Based for Primary Schools

During the implementation period of the Standard-Based Curriculum for Primary Schools, a recognized need emerged to enhance and fortify the curriculum to align with the recommendations of the Malaysian Education Blueprint 2013 - 2025. As a result, the Standard-Based Curriculum for Primary Schools (Revised 2017) was developed in stages, commencing with Year 1 in 2017. This curriculum transformation aimed to integrate effective learning programs, enhancing student outcomes to achieve six key aspirations: knowledge, thinking skills, leadership skills, bilingual skills, ethics and spirituality, and national identity. This comprehensive transformation encompassed distinct improvements in content, pedagogy, and assessment, creating an overarching advancement in primary education.

The Standard-Based Curriculum for Primary Schools undergoes meticulous content restructuring and enhancement, designed to equip students with pertinent knowledge, skills, and values crucial for addressing the challenges of the 21st century. The pedagogical approach prioritizes in-depth learning grounded in HOTs (Zakaria et al., 2021). This approach integrates various teaching and learning methodologies, including inquiry-based (Riegle-Crumb et al., 2019), problem-solving (Hasram et al., 2020), contextual (Zuber &

Altrichter, 2018), collaborative (Zamili, 2021), project-based (Vanhala, 2018), and STEM methodologies (Sutaphan & Yuenyong, 2019). Assessment is conducted continuously to ensure continuous advancement in student learning. This comprehensive assessment process documents and communicates the progress and attainment of students' mastery levels, offering descriptive feedback to students and parents. This integrated approach in content, pedagogy, and assessment fosters holistic student development, preparing them to excel in the modern world.

In implementing the revised version of the Standard-Based Curriculum for Primary Schools, a pivotal document known as the Curriculum and Assessment Standard Documents places significant emphasis on HOTs (Eka, 2020). HOTs pertain to applying knowledge, skills, and values in reasoning and reflection to solve problems, make decisions, and engage in innovation and creativity. Bloom's Taxonomy delineates six levels of thinking, with skills such as applying, analyzing, evaluating, and creating skills falling under the category of HOTs (Sole & Anggraeni, 2020). Despite the importance of mastering HOTs in Science learning, it has emerged as a notable challenge for pupils (Panggabean et al., 2021). The development and enhancement of HOTs in Science education are paramount for cultivating students' critical thinking and problem-solving capacities, thus preparing them to thrive in an ever-evolving world.

2.2.3 Science Classroom

According to Alneyadi (2019), Science education is a process that enables pupils to comprehend and interpret the world while formulating scientific claims. Within Science learning, teachers play a pivotal role in guiding pupils to master scientific practices and

comprehend the essence of scientific inquiry within the classroom (Sutiani, 2021). Pupils have the right to acquire proficiency in the language of Science and become scientifically literate individuals (Piacentini, 2021). Empowering pupils with these skills and knowledge is essential for fostering a scientifically informed society and cultivating critical thinking and problem-solving abilities among learners.

Effective communication between teachers and pupils is crucial in the Science classroom. Teachers significantly contribute by imparting scientific knowledge and perspectives to the classroom, aiding pupils in developing conceptual understanding through investigations and evidence-based reasoning (Antonio & Prudente, 2021). In response, pupils actively engage in scientific skills and strive to form their interpretations of scientific concepts. This interactive and participative approach empowers pupils to take ownership of their learning and develop a deeper understanding of scientific principles.

In modern Science classrooms, pupils are expected to express scientific ideas using the language of Science (Pietarinen et al., 2021). Effective teacher-pupil interaction is crucial to facilitating more meaningful learning experiences, enabling pupils to develop proficiency in the language of Science alongside their scientific understanding. Teachers can enhance pupils' scientific language skills by encouraging active engagement and clear communication, fostering a deeper grasp of scientific concepts and promoting effective scientific communication.

According to Birkland (2021), Science classrooms require additional elements to ensure functionality and safety, facilitating effective Science learning for teachers and pupils. Emphasizing the importance of suitable facilities and resources is vital to providing all learners equal opportunities to acquire scientific knowledge (Gonda-King, 2022). Hands-on learning experiences are integral to Science education, necessitating the

availability of appropriate facilities and resources to offer essential learning experiences for pupils (Nantsou et al., 2021; Berke et al., 2021; Selco, 2020; Rezlescu et al., 2020; Furtak & Penuel, 2019; Kalogiannakis et al., 2018). To support hands-on learning, Science classrooms should be adequately spacious to accommodate pupils conducting activities (Talukder et al., 2021; Wade-Jaimes, 2021). Teachers must adopt pedagogical approaches that engage pupils in Science learning within suitable classroom spaces. Moreover, modern Science classrooms can be designed flexibly to facilitate the effective teaching of the Science curriculum to pupils. Educators can enhance pupils' engagement and comprehension in Science education by ensuring that Science classrooms are well-equipped and designed to promote active learning experiences.

As underscored by relevant studies, Science classrooms have become more effective through technology integration (Ramaila & Molwele, 2022; Tanik Önal, 2021). Implementing Technology-Enabled Active Learning (TEAL) pedagogical approaches, which utilize technology, hands-on activities, and small group work, is effective (Hassan et al., 2020). Similarly, Technology Enhanced Model-Based Instruction (TMBI) leverages technology and group learning to enhance performance in STEM education (Hutchin et al., 2019). By incorporating technology into the Science classroom, pupils can engage in individualized practice and receive personalized feedback on their responses, contributing to an improved standard of Science Education (Saadu, 2022). Technology as an educational tool enables innovative teaching methods and a more interactive learning experience, positively impacting pupils' engagement and comprehension of Science.

2.3 Teaching and Learning Approaches in Science Education

2.3.1 Inquiry-Based Science Learning

Inquiry-based learning is a teaching and learning approach that systematically guides pupils in solving problems, encouraging teachers to provide freedom and autonomy to create sustainable and suitable solutions (Nugroho & Zulfiani, 2021). This approach can potentially optimize pupils' learning outcomes, promoting self-reflection and the ability to find answers or solutions to problems using provided clues. In alignment with this approach, the MOE has introduced inquiry-based Science teaching to incorporate HOTs elements in the classroom (Michalsky, 2021). One of the models utilized to implement inquiry-based Science learning is the 5E Instructional Model, consisting of five crucial phases: engagement, exploration, explanation, elaboration, and evaluation (Ong et al., 2018). This model enhances pupils' learning experiences in the Science classroom, encouraging active engagement and a comprehensive understanding of scientific concepts through a structured and systematic approach. By incorporating inquiry-based learning and employing the 5E model, educators can enhance pupils' critical thinking skills and overall learning outcomes in Science education.

2.3.2 Conventional Teaching (CT)

PowerPoint has become widely utilized as one of the most common software in educational settings across all levels of classrooms (Uzun & Kilis, 2019). However, certain studies highlighted drawbacks and criticisms associated with PowerPoint presentations. For instance, some teachers read verbatim from the slides, leading to a lack of engagement in classroom discussions (Anderson & Marklund, 2023). Furthermore, this approach might discourage students from asking questions and participating actively during the

presentation. Relying too heavily on PowerPoint slides can impede teachers from effectively employing other instructional methods (Kartal & Başarmak, 2022; Forde & Obrien, 2022). Additionally, students may become overly focused on the PowerPoint slides than the instructions provided by their teachers, resulting in decreased motivation to actively engage in the learning process (Priyaadharshini, 2020; Barwasser et al., 2021). These criticisms underscore the importance for teachers to balance utilizing PowerPoint effectively, ensuring that it complements rather than replaces other teaching methods to encourage active student engagement and participation in the classroom.

2.3.3 Computer-Supported Collaborative Learning (CSCL)

The exploration of CL methods on a global scale, including the integration of technologies, has been extensively studied (Chamorro-Atalaya et al., 2022; Mshayisa, 2022; Batra & Kumar, 2022; Lock & Redmind, 2021). In e-learning systems, two main categories are commonly identified: learner-centred and Computer Supported Collaborative Learning (CSCL). CSCL involves activities teachers facilitate to encourage increased interaction and mutual engagement among pupils or learners toward achieving the learning objectives (Radkowitsch et al., 2020). This CL approach is underpinned by information and communication technologies (Talan, 2021). By incorporating CSCL in educational settings, educators can create a more interactive CL environment, leveraging technology to enhance communication and engagement among learners.

The use of computers in CSCL is well-supported, as it stimulates interaction and learning among learners (Ma et al., 2023). However, it is important to note that CSCL is not solely about delivering information but focuses on fostering meaningful interactions

among pupils in the classroom (Schnaubert & Bodemer, 2022). Assessing CSCL involves considering five main perspectives: participative, interactive, social, cognitive, meta-cognitive, and teaching dimensions. CSCL can be defined as an approach that facilitates e-learning and emphasizes meaningful interactions among pupils, driven by communication and mediated by artefacts (Kaliisa et al., 2022). This approach encourages collaborative problem-solving and enables learners to acquire new knowledge through interactions with their peers in the CSCL environment (Lin & Lin, 2019). Overall, CSCL leverages technology to create an environment that nurtures collaboration, communication, and meaningful learning experiences among pupils.

2.3.3.1 Collaborative Learning (CL)

In contemporary education, pupils are increasingly exposed to group learning experiences as this approach gains prominence across all levels of schooling (La Hanisi et al., 2018). CL is a form of group work that involves small groups of pupils, promoting active engagement in the learning process (Sumtsova et al., 2018). This approach requires pupils to collaborate and complete specific tasks within their groups, often utilizing discovery-based methods (Saif et al., 2021) to achieve their learning goals in the science classroom (Kumiasih, 2022). Teachers are crucial in facilitating CL activities, to create a conducive environment where pupils can effectively collaborate and learn from one another (de Hei et al., 2020). By implementing CL, educators can foster collaborative skills, critical thinking, and effective communication among pupils, equipping them with valuable abilities for success in the modern world.

CL involves pupils learning together in pairs or small groups to collectively achieve the learning goals in the science classroom (Supena et al., 2021). CL has three main features: intentional design, co-labouring, and meaningful learning (Major, 2020). The intentional design allows pupils to work together as a team, creating their activities while utilizing existing strategies provided by teachers. Meaningful learning ensures that all pupils, acting as learners in teams, share the common aim of improving their understanding of the subject matter, such as Science (Kaden, 2020). CL emphasizes co-labouring, where teammates collaborate and share knowledge without the requirement to shift responsibilities solely based on the pupils' inability to achieve learning goals in the classroom. This approach fosters an environment where pupils can actively engage with one another, exchange ideas, and collectively deepen their comprehension of the subject matter, particularly science (Ramirez, 2021). By embracing CL, educators can encourage collaborative skills and enhance pupils' overall learning experiences, promoting a more effective and engaging science classroom environment (Lombardi, 2021).

CL in the classroom offers several advantages. First, CL approaches, such as social collaboration theme-based project collaboration (Urrea et al., 2022) and peer activities like peer helping and peer tutoring (Novak et al., 2022), can be effectively applied among pupils in the Science classroom. These collaborative approaches contribute to pupils' learning and growth, requiring teachers to create supportive environments by implementing CL. The effectiveness of CL is further supported by Meng and Wang (2019), who highlighted its alignment with independent, cooperative, and inquiry-based learning methods commonly employed by educators today. This alignment has resulted in improved outcomes among pupils, demonstrating the positive impact of CL on their learning experiences and overall academic performance, particularly for science subjects

(Wang et al., 2020; Warsah et al., 2021). Educators can create a more dynamic and engaging learning environment by incorporating CL approaches in the classroom, promoting pupils' active participation and fostering a sense of cooperation and collaboration among students.

Recently, CL has evolved as a field that benefits from technological advances, leading to improvements and innovations in the classroom's teaching and learning process (Mivehchi & Rajabion, 2020; Alonso et al., 2019). Within a CL environment, pupils can easily share and access learning content, including text and pictures, facilitated by electronic devices and wireless communications (Zhang & Zou, 2022). This technology integration allows pupils to engage in learning and foster peer collaboration actively. Moreover, CL enables pupils to utilize electronic devices to acquire scientific knowledge (Mystakidis et al., 2021). The approach can be further enhanced by incorporating location-based learning platforms (Asakle & Barak, 2022) and game-based learning strategies (Adipat et al., 2021). By leveraging these technological resources, educators can create dynamic and interactive learning experiences, enhancing pupils' engagement, knowledge retention, and overall learning outcomes. The combination of CL and technology offers a promising pathway to transforming traditional science classrooms into more student-centred, collaborative, and technologically empowered learning environments (Bature, 2020; Zairul, 2020).

2.4 Social Interaction in the Classroom

Social interaction in the classroom can be described as a unique form of external influences that impact an individual's preferences and actions (Engelbrecht et al., 2020).

Eriksson et al. (2021) define social interaction as events in which people assign significance to a situation, enabling them to understand others' explanations and provide feedback accordingly. Furthermore, they assert that positive social interaction can be nurtured by establishing supportive and enduring social relationships (Fiş Erümit, 2021). A conducive and supportive social environment in education can contribute to more effective communication, collaboration, and overall learning experiences among students.

Positive social interactions among individuals can lead to diverse positive outcomes, including enhanced subjective well-being (Gunaydin et al., 2021). Good social interaction can also improve individuals' cognitive and language development (Hult, 2019). This supports the idea that teaching and learning processes are increasingly recognized as social accomplishments, and interactions between teachers and pupils play a significant role in the Science classroom today. A conducive social environment in the classroom fosters effective communication, collaboration, and learning experiences, ultimately benefiting teachers and pupils in their academic and personal development.

Social interaction holds a significant role in the learning process for pupils in the classroom. Interacting with their peers enables pupils to organize their thoughts, reflect on their understanding of scientific concepts, and identify gaps in their reasoning (Tocaimaza-Hatch & Santo, 2020). This notion is further supported by Valiente et al. (2020), who emphasize that young learners acquire a range of skills through social interactions with their peers, including comprehension of social roles, sharing, communication, and appropriate responses to various situations. By encouraging and fostering positive social interactions, educators can enhance pupils' cognitive and social development, leading to more effective learning experiences in the classroom.

Harari et al. (2020) have categorized social interaction into three main components: descriptions of actions and behaviours, sociability and participation, and exploration of social relationships among pupils in the classroom. First, the descriptions of actions and behaviours refer to the observable actions, behaviours, and verbal exchanges that occur among pupils in the classroom setting. It includes activities such as speaking, listening, asking questions, answering queries, sharing ideas, and collaborating on tasks. Also, it encompasses both individual contributions and interactions within groups, providing insights into how pupils engage with each other during learning activities. Secondly, sociability and participation focus on the extent to which pupils actively engage with their peers and participate in social interactions within the classroom. It involves aspects such as initiating conversations, joining group discussions, offering assistance to classmates, and demonstrating cooperative behaviours. Sociability reflects the willingness of pupils to interact with others, while participation denotes the degree to which they involve themselves in social exchanges and collaborative endeavours. The third component, exploration of social relationships involves the investigation and understanding of the social relationships that develop among pupils in the classroom context. It includes examining patterns of friendship, group dynamics, social hierarchies, and peer affiliations. Exploration of social relationships aims to uncover the nature and quality of interpersonal connections among pupils, including factors such as trust, empathy, cooperation, and conflict resolution skills.

According to Qureshi et al. (2023), the communication process in the classroom predominantly occurs from the teacher to the pupils, influencing their perceptions of Science learning. However, despite spending hours receiving teacher instructions, pupils are often expected to generate their ideas and engage in oral discussions in the classroom

(Francisco & Alieto, 2022). As a result, solely emphasizing students' observable behaviours in the classroom is insufficient for researchers to understand the complexities and dynamics of social interaction in Science learning. The multifaceted nature of social interaction in the classroom calls for a comprehensive approach considering verbal and non-verbal exchanges, sociability, and social relationships among pupils.

Science teachers play a crucial role in the classroom, requiring them to possess social skills and facilitate meaningful interactions with their pupils during Science lessons (Hymel & Katz, 2019). However, it is noted that many teachers do not frequently explore or employ effective strategies to address the issue of social interaction with pupils within their educational practices (Azmat & Ahmad, 2022). This suggests a potential area of improvement for teacher training and professional development, where educators can be equipped with tools and techniques to enhance their social skills and create a more engaging and supportive learning environment for their pupils. Emphasizing the significance of social interaction in the classroom can improve student engagement, communication, and overall learning outcomes.

However, despite its importance, there are several potential research gaps that merit further exploration. Firstly, while existing literature provides insights into the components and outcomes of social interaction in the classroom, there remains a need for more comprehensive approaches to studying its complexities. Researchers could explore verbal and non-verbal exchanges, sociability, and social relationships among pupils to gain a deeper understanding of classroom dynamics. Secondly, there is a need to address the role of teachers in facilitating meaningful social interactions. Teacher training and professional development programs could focus on equipping educators with the necessary skills and strategies to promote positive social engagement and create inclusive learning

environments. Additionally, future research could delve into the impact of social interaction on specific aspects of Science education, such as conceptual understanding, problem-solving abilities, and academic achievement. By examining these factors, researchers can elucidate the mechanisms through which social interaction influences learning outcomes.

2.5 Gamification in the Education Field

2.5.1 Paper-Based Board Games (PBBG)

Gennari et al. (2019) define board games as games involving cards, plates, dice, or other elements played on a table. Board games have developed over a century from parent-child interactions in Europe and the U.S. (Musick et al., 2021). In Taiwan, Kuo and Hsu (2020) underscore social media's role in guiding board game play and using board games to enhance teaching professionalism through classroom observation and teaching program design. Board games are evolving as an organized teaching tool in Taiwan.

Zakaria et al. (2022) assert that a board game acts as a learning catalyst, providing insights for parents and teachers into pupils' learning processes. The researchers also acknowledge that board games can enhance cognitive learning and ignite curiosity about specific subjects, stimulating discussions (Manshoven & Gillabel, 2021). The content of board games may focus on imparting knowledge in a particular domain or emphasize problem-solving in a highly engaging context. Overall, board games offer a valuable educational tool to engage pupils, promote active learning, and cultivate critical thinking skills within an enjoyable and interactive learning environment.

Ab Rahman et al. (2018) discovered that incorporating board games in the prototype development phase garnered 96% of student interest and motivation. Board games encourage group participation (Hou & Keng, 2021) with user-friendly rules that facilitate full involvement. In contrast to competitive games, board games create a collaborative and engaging learning environment, reducing pupil anxiety (Nigora & Fotima, 2022; Wong & Yunus, 2021). Effective use of board games entails warm-up activities, clear instructions, tasks, and reflection (Russo et al., 2021) to enhance the learning experience. Skillfully integrating board games enhances pupil motivation and boosts active classroom engagement.

Board games offer multiple advantages, nurturing social learning abilities, assessing skill proficiency, and fostering community-sharing experiences (Syawaluddin et al., 2020; Morales & Vázquez, 2022; Parjanen & Hyypiä, 2019). Pupils comprehend game content and rules, expanding their learning capacities, while educators can adapt game rules to meet teaching objectives. Board games enhance classroom perception, social abilities, language acquisition, motor skills, and emotional development (Bustamante et al., 2020). Board games provide a comprehensive learning experience, influencing cognitive, social, and emotional growth.

Board games, when well-designed, create an attractive atmosphere and enhance social interaction skills (Zou et al., 2021). They promote teamwork (Azizan et al., 2018) and decision-making (Ghoman et al., 2020) among learners. Moreover, board games foster healthy competition, cultivating positive attitudes towards success and failure (Douglas & Brauer, 2021). Failure prompts reflective thinking, leading to deeper understanding and continuous learning. Board games offer dynamic and enjoyable learning experiences that stimulate multiple skills and competencies.

Similarly, Parks (2003), whose research involved the design of "Aerobic Respiration: The Board Game" for biology learning with 30 undergraduate students. Results indicated that the participants had significantly favourable perceptions of the board game as a learning tool, enhancing their motivation to learn cellular respiration pathways. However, Parks' study solely focused on learning motivation and did not consider academic performance or social interactions in the investigation.

Alejandria et al. (2023) demonstrated the benefits of a chemistry board game for senior high school students at UM Digos College, with a significant post-test mean difference between the control group (using traditional teaching methods) and the experimental group (using the board game) in learning the periodic table of elements. Although the study indicated the board game's effectiveness as a supplemental learning tool, it lacked qualitative data from classroom observation or interviews, limiting a comprehensive understanding of students' experiences.

Assapun and Thummaphan (2023) used board-game-based learning with lower secondary students to enhance their problem-solving competency in STEM education. Positive results included increased problem-solving behaviour, improved skills scores, positive learning experiences, and high social interaction. However, this research did not investigate academic performances and learning motivations, leaving room for further exploration.

Miculob et al. (2022) reported similar outcomes with secondary Science students using the ATP Quest board game, showing significant improvements in summative exam scores. However, this research focused on secondary students, and research instruments such as questionnaires, classroom observation, and interviews were not used, limiting data collection.

Murray et al. (2022) designed the "Diamond: The Game" board game for secondary school students, emphasizing participants' engagement as active agents. Although relevant to secondary education, the board game's focus was not on primary Science, centring on social interaction rather than direct relevance to primary Science education.

Cardinot and Fairfield (2022) applied the Novel astronomy board game to post-primary students, yielding promising results for game-based approaches in physics education. However, this research also lacked consideration of academic achievements and learning motivation, concentrating solely on social interaction.

Botes (2022) found positive impacts on personal skill development in teaching natural Science using educational Science board games with final-year pre-service teachers. However, this research did not focus on primary school students and extensively analyses academic performances and learning motivation.

Chiang et al. (2022) observed significant knowledge, attitude, and behaviour increases related to food and nutrition educational board games with middle school students. Despite similarities, this research included primary school students, unlike Chiang et al.'s research.

Sangwanna et al. (2022) developed the Fruit-Veggie Wonderlands Board Game, receiving high satisfaction from students regarding game enjoyment, aesthetics, preference, duration, and ease. However, this research used only physical board games with the participants, while this research considered exploring paper-based and computerized versions of board games.

Stanley's study (2022) also found a significant association between students' perception and learning effectiveness when using a board game on "Carbon Compound".

The students agreed that the game made the lesson more exciting and helpful. However, unlike this research, Stanley's research did not include the application of a digital version of the board game, limiting the comparison and analysis of the effectiveness of both types of board games.

Montejo and Fernández (2021) developed the Chemical Battleship Board Game for learning the periodic table. This aligns with this research's approach of using PBBG with CL to assess acceptance level, interest, and knowledge. The findings showed high acceptance in both groups, with increased interest and curiosity in the first group and improved knowledge in the latter group. Students' subjective perception of their knowledge improved, and their marks reflected an enhancement in understanding the periodic table. However, this research only involved secondary school students, while this research focused on primary Science education.

Aliyu et al. (2021) created the Symperiod Board Game to assess students' understanding of chemical symbols and the periodicity of elements among 20 Form IV students. The findings indicated that group members showed excellent cognitive improvement in learning periodicity using the Symperiod board game after conducting pre-test and post-test. However, this research did not utilize other research instruments like questionnaires, classroom observation, and interviews, which could have provided more comprehensive data for analysis.

Parekh et al. (2021) used an educational board game with Hispanic and Caucasian boys aged 13 to 17 as participants. The research instruments included field notes, video and audio recordings of team discussions, notes, sketches, game artefacts, and class observation. The findings showed that designing board games in authentic contexts

engaged youth in building models and system thinking, fostering positive social interaction. However, the study did not use pre-test and post-test assessments or questionnaires for quantitative data collection and analysis.

Chen et al. (2021) developed the "Element Enterprise Tycoon" board game for chemistry learning. Forty-eight high school students participated, and most students' CPS skills, especially in solution-finding, increased. Interviews showed improvements in conceptual dimensions and interactivity, leading to creative ideas from various perspectives compared to traditional teaching methods. However, the study did not use questionnaires, pre-test, post-test assessments, or classroom observation for additional data collection.

This research aligned with Deta et al. (2021) in providing a physical, educational board game for physics learning. It found that certain educational physics games, particularly "board games and cards," were highly effective in improving student learning outcomes. However, the study did not compare the board game with a digital version or traditional teaching method in terms of mean scores.

This research was consistent with Tsai et al. (2021), as the "Be Blessed Taiwan" Board Game was used to teach sustainable development, specifically biological conservation, to high school students. The findings showed a significant increase in test scores compared to CT methods, with a large effect on biodiversity concepts and a medium effect on biological conservation concepts. However, this research did not involve primary school students and used only pre-test and post-test assessments for data collection.

This research aligned with Meekaew and Yasri (2020), where the "MicroEvo" board game was used to enhance high school students learning performance of

microevolution. Pre-test and post-test assessments were used, and the findings indicated a statistically significant improvement in mean scores from 12.35 to 15.39. The game also led to an increase in scientifically accurate answers and a decrease in misunderstandings. However, this research solely focused on pre-test and post-test assessments, and other research instruments were not utilized to explore learning motivation and social interaction among the participants.

Dziob's study (2020) mentioned that physical board games were used to assess the knowledge of Polish students in a physics course. The experimental group performed better in the post-test than the control group, indicating increased knowledge through board game play. However, this research did not explore learning motivation and social interaction among the respondents. To gain a comprehensive understanding, it is recommended to use questionnaires, classroom observation, and interviews for analysis in future research.

Fjællingsdal and Klöckner's (2020) study was similar to this research, involving 17 respondents on board game nights to play environmental board games of their choice. Focus group interviews were conducted to explore gameplay experiences and learning outcomes. The findings revealed that the board games increased participants' awareness of the connection between their actions and their impacts on the game board. Additionally, the board games facilitated social interaction among players in a physical setting. However, this research did not use other research instruments, such as questionnaires and pre-test and post-test assessments, to explore the participants' academic performances and learning motivations.

Sari and Rezeki (2019) stated that an ingenious circuit board game was created to teach chemistry. Data collection included questionnaires and observations, with 90% of

students responding positively and 89.29% of teachers showing good responses. Similarly, this research also uses questionnaires, classroom observation, and interviews, demonstrating higher learning motivation. However, unlike Sari & Rezeki's study, this research does not focus on Science learning for primary school students.

Butsarakam and Yasri (2019) used the Female Reproductive (FEREP) Board Game to investigate its effectiveness on 10th-grade students' conceptual understanding and attitudes toward learning the menstrual cycle. Similar to this research, it employed pre-test and post-test assessments, followed by a questionnaire, which revealed that the board game improved conceptual understanding and positive attitudes toward learning. However, this research did not use qualitative methods to assess the students' learning motivations regarding the menstrual cycle concept.

Board games can extend beyond Science education, as demonstrated by Cutumisu et al. (2019) who found that learning neonatal resuscitation through a physical board game improved participants' knowledge and performance in resuscitation situations based on post-test results. However, this research did not focus on learning motivations and social interactions among the participants.

Regarding language learning, Lodzikowski and Jekiel (2019) created a physical board game on English prosody for university students learning English as a foreign language in Poland. Implementing the board game led to a moderate increase in students' post-game class exam scores compared to those in the traditional class. However, this research focused on English subjects among university students and used pre-test and post-test assessments as the data collection method.

In addition to Science education, the findings of Pinhatti et al. (2019) indicated that using a physical board game proved to be a new and enjoyable learning approach for participants. The questionnaire responses indicated growth and improvement in class engagement, learning process enhancement, and social interaction during diagnostic imaging classes. However, the effectiveness of the board game implementation requires further investigation, as the study did not include other research instruments, such as pre-test and post-test assessments for quantitative data analysis.

The study by Cardinot and Fairfield (2019) showed that their development and use of a board game in astronomy facilitated students' understanding of concepts and promoted social skills. Teachers also showed positive attitudes toward the board game implementation. However, this research did not explore students' learning motivations in-depth.

Ade Maulana (2019) conducted a study on implementing board games to enhance English-speaking ability among 32 Seventh Grade students. The research instruments included a speaking test, observation sheet, interview, and documentation, showing improvement in students' English-speaking ability. However, the study focused solely on speaking ability, while board games can be applied to various topics or subjects.

Hence, it is important that those researches on the use of board games in education have highlighted several key findings and areas for improvement. Board games have shown promising results in enhancing learning outcomes across various subjects, including Science, language learning, and other academic disciplines. They have been found to improve students' knowledge retention, problem-solving skills, and overall academic performance. Board games foster active engagement and social interaction among students, promoting teamwork, communication, and collaboration. They create an enjoyable and

interactive learning environment that encourages participation and reduces anxiety, particularly in competitive settings. Incorporating board games into educational settings increases students' motivation to learn and participate in classroom activities. The interactive nature of board games stimulates curiosity, fosters intrinsic motivation, and enhances students' interest in learning. Board games offer a versatile teaching tool that can be adapted to various educational contexts and learning objectives. They cater to diverse learning styles and preferences, providing opportunities for differentiated instruction and personalized learning experiences. Hence, both pupils and educators perceive board games positively as an effective instructional strategy. They appreciate the immersive and hands-on learning experiences facilitated by board games, which complement traditional teaching methods and enhance overall learning outcomes.

While existing research has demonstrated the benefits of using board games in education, there are areas that warrant further investigation. Future studies could explore the long-term effects of board game interventions on academic achievement, motivation, and skill development. Additionally, research could examine the optimal design principles and instructional strategies for maximizing the educational benefits of board games across different age groups and subject areas. Overall, board games offer a promising approach to enhance teaching and learning experiences, fostering student engagement, collaboration, and critical thinking skills. By leveraging the interactive and immersive nature of board games, educators can create dynamic and effective learning environments that cater to the diverse needs of students.

2.5.2 Computerized Board Games (CBG)

Digital games share similarities with game-based learning methods and have gained recognition as effective approaches for enhancing pupils' learning performance (Wang & Zheng, 2021). Educational computer games have been successfully employed to bolster learning in mathematics (Soboleva et al., 2021) and natural Science (Cook-Chennault et al., 2022). By combining technology with gaming mechanics, digital games offer an innovative pathway for education (Pondee et al., 2021).

Digital game-based learning implementation has improved pupils' learning interest and motivation (Liu et al., 2020). They provide an engaging and stimulating environment surpassing conventional technology-enhanced learning (Gök & İnan, 2021), allowing players to explore outcomes and predict results, igniting a desire to acquire new knowledge. Teachers need to recognize that the content within digital board games should be conducive to learning, promoting mutual influence and knowledge enhancement. While some digital games may have negative impacts, such as excessive use by young learners in real life (Parsons et al., 2019), integrating pro-social digital games within the classroom can foster better understanding (Beavis et al., 2021) and contribute to long-term academic performance (Douglas & Brauer, 2021), even enhancing prosocial skills among students through cooperative learning.

The prevalence of digital games in classrooms has surged, marked by their engaging game play and advanced graphics (Duthie et al., 2021). However, the precise impact of digital games on education remains somewhat uncertain, presenting benefits and potential pitfalls (Gürsoy, 2021). Research on the effects of digital games on education,

teaching, learning, and pupil achievement yields mixed, intricate, and inconclusive results (Tokarieva et al., 2019).

Pupils can acquire knowledge through technology-enabled practical experiences (Yates et al., 2021). Digital games have shown promise in fostering collaboration (Wang & Huang, 2021), enhancing problem-solving skills, promoting effective communication (Deng et al., 2020), and encouraging self-identity exploration among students, facilitating their overall learning experience (Foster et al., 2019). Integrating digital teaching resources with traditional methods is crucial for developing meaningful and inclusive teaching strategies (Biletska et al., 2021). However, students must enhance their digital skills and competencies to fully harness the benefit of digital games in the classroom (Mehrvarz et al., 2021).

Digital games offer promising avenues to supplement various courses, although coordinating the variables influencing learning outcomes in the classroom can pose challenges. Despite this, the explicit evaluation of learning outcomes in Science subjects has recently been limited (López Carrillo et al., 2019). Prokhorov et al. (2022) showed an intriguing example of a 3D simulation game, which was employed to assess the digital competency levels among applicants and first-year students. This led to the creation of a career guidance 3D quest game. While this initiative elevated motivation to learn, particularly among those with higher language achievement, the absence of comprehensive explanations of the collected works for learners impeded the games' overall success, making it challenging to gauge learning outcomes and parameters correlated with improved classroom learning (Lin et al., 2020).

Mobile learning involves using electronic devices such as smartphones, tablets, and laptops to extend traditional teaching and learning into the digital realm. It constitutes a form of e-learning where digital content is delivered to students, enabling learning activities to thrive (Montiel et al., 2020; Moca & Badulescu, 2021). These devices facilitate feedback between teachers and students, fostering a deeper grasp of the learning process, especially when paired with digital games (Rakhmatov, 2021). The potential of electronic devices establishes a strong connection between classroom and home study, enhancing engagement and learning experiences, particularly when iPads or tablets are employed(Hover & Wise, 2022; Parkash, 2022). Educators leverage electronic devices to effectively support learning processes through digital games inside and outside the classroom (Dewi, 2022).

Nevertheless, it is important to acknowledge that challenges exist. Limited broadband wireless access can hinder mobile learning in some classrooms (Punako, 2018), and cross-platform inconsistencies in mobile devices may present drawbacks (Antropov & Czapinska, 2019). Multitasking during mobile learning might lead to distractions and hinder the retention of learning content (Pedro et al., 2018).

Mobile Computer-Supported Collaborative Learning (MCSCL) is an approach that can be promoted in the classroom (Santosa et al., 2020). Effective collaboration tools via mobile technologies should be meticulously designed to facilitate pupil interaction and scaffold learning activities (Pareto & Willermark, 2022).

Soewono et al. (2022) focused on "ATtack Covid Game" as an online and electronic board game. The study involved 11 high school students and found that the

game was widely enjoyed. However, their research did not assess the game's effectiveness on the participants' academic performances, learning motivation, and social interaction.

Lin and Cheng (2022) delved into applying technology-enhanced board games in Mathematics education for primary school students, unveiling heightened technology acceptance and increased learning motivation. However, their study focused exclusively on Mathematics education, leaving out academic performance and social interaction aspects, and did not specifically explore Science education.

Hayati et al. (2022) focused on using the Sciencemopoly Game in teaching the digestive system topic to junior high school students. Questionnaire results indicated that the participants perceived the game as a suitable teaching media for Science, with high scores in both product trial (4.08) and field trial (4.39) categories. However, the study focused solely on learning motivation and did not assess social interactions or academic performances in Science education.

An innovative study by Lin et al. (2021) introduced an Augmented Reality (AR) integrated health education board game, demonstrating significant improvements in learning motivation influenced by AR integration. Nonetheless, this research exclusively utilized digital versions of the board game, and a paper-based version should be included for comprehensive statistical comparison. Furthermore, future studies should consider academic performances and social interaction features for thorough analysis.

Similarly, Ang et al. (2020) developed physical and digital educational escape rooms to teach chemical bonding. While promising outcomes were observed, the study did not assess academic performances, learning motivation, or social interactions.

da Silva Júnior et al. (2020) introduced a multilingual hybrid board game that involved pharmacy undergraduate students. The findings indicated positive feedback on design, content, playability, usability, and usefulness in learning intermolecular forces. However, this research was conducted with undergraduate students, and its application to primary school students was not explored.

Kuo and Hsu (2020) developed the Robot City Board Game for teaching computational thinking. The findings emphasized enhancing interaction and higher-level thinking among students, improving learning achievement. However, this research solely focused on social interaction, with other factors, such as academic performance and learning motivation, unexplored.

Premthaisong and Srisawasdi (2020) developed a multi-player digital board game for third-grade students in Thailand, revealing positive acceptance and perceptions of the learning experience. However, a more comprehensive approach involving questionnaires, classroom observations, and pre-test and post-test assessments could provide a deeper understanding.

Chen (2017) explored digital games' impact on learning motivation and achievement, yielding positive effects. However, the study was not conducted among primary pupils in Malaysia and did not encompass board games.

There are several potential research gaps that could be addressed to strengthen our understanding and implementation of digital game-based learning. Firstly, while existing studies have highlighted the benefits of digital games in improving learning motivation and interest, there is a need for more comprehensive evaluations of their impact on academic performance and social interaction. Future research should explore these aspects to provide

a more holistic assessment of digital game-based learning interventions. Secondly, there is a lack of studies specifically focusing on the integration of digital games in Science education, particularly in primary school settings. Investigating the effectiveness of digital games in teaching Science concepts and promoting social interaction among younger students could provide valuable insights for educators and policymakers. Additionally, research on digital game-based learning often overlooks potential drawbacks and challenges associated with their implementation, such as limited access to technology and cross-platform inconsistencies. Future studies should address these issues to ensure equitable access to digital learning resources and maximize their effectiveness in diverse educational settings. Moreover, while some studies have explored the benefits of digital games in enhancing collaboration and problem-solving skills, there is a need for more research on the design and implementation of collaborative learning activities within digital game environments. Investigating how digital games can facilitate peer interaction and cooperative learning experiences could further enhance their educational value.

2.6 Gender Differences

2.6.1 Conventional Teaching (CT)

CT, especially PowerPoint presentations have become integral in educational settings, offering a dynamic platform for information delivery and interactive learning (Choi et al., 2021). Understanding how gender differences influence this learning environment is essential for educators and researchers today.

In view of gender-based performance, existing research indicates that gender differences in academic performance might affect pre-test and post-test results (Maniam et

al., 2023; Enikanolaye, 2021; Radzuan et al., 2021; Tan et al., 2020). Gender differences can influence cognitive styles (Asy'ari & da Rosa, 2022; Trollinger, 2021; Anggrawan & Nuraini, 2021; Rusdi et al., 2020). Some studies suggest that males may lean toward competitive or analytical thinking, while females might adopt cooperative or holistic approaches (Reynolds, 2022; Cigarini et al., 2020; Petre, 2020). These cognitive styles may affect information processing during PowerPoint-based learning. However, there were some previous studies stated that there were no gender differences in different fields (Shawaqfeh et al., 2020; Namaziandost & Cakmak, 2020; Chiquito et al., 2020; Ja'ashan, 2020; Wynter et al., 2019).

Social interaction in the classroom, particularly during teaching and learning activities facilitated by PowerPoint presentations, can reveal gender differences (Namaziandost & Cakmak, 2020). Males and females may exhibit varying communication and collaboration styles during these interactions. Research indicates that males often adopt assertive and direct communication styles. They may be more inclined to express their ideas and opinions confidently and assertively during classroom discussions or group activities. Also, males may prioritize conveying information succinctly and directly, focusing on problem-solving and task-oriented communication. In contrast, females may exhibit more collaborative and inclusive communication styles. They might engage in active listening, seeking to understand others' perspectives and fostering a supportive and inclusive communication environment. Additionally, females may prioritize building rapport and consensus, employing empathy and emotional intelligence in their interactions. On the other hands, males may approach collaboration in a competitive or hierarchical manner, seeking to assert their ideas and leadership within group settings. They may prefer structured roles and clear objectives, emphasizing efficiency and results-oriented

collaboration. Males may engage in task-focused collaboration, prioritizing productivity and achievement. However, females often adopt more cooperative and consensus-driven collaboration styles. They may emphasize relationship-building and collective decision-making within groups, striving for inclusivity and consensus. Females may prioritize building supportive relationships and fostering a sense of community within collaborative endeavours. However, some educators still utilize PowerPoint presentations and conduct one-way communication in the classroom nowadays (Creely & Lysons, 2022; Ajuluchukwu & Osakwe, 2019).

Gender differences in learning motivation may manifest as variations between intrinsic and extrinsic motivation (Shubina & Kulakli, 2019; Zaccone & Pedrini, 2019). Understanding whether males or females are more intrinsically or extrinsically motivated in PowerPoint-based learning can aid in tailored instructional approaches. Students' perceptions of how PowerPoint presentations relate to their interests and real-life applications can influence their motivation (Elhouar, 2023). These perceptions may differ by gender (Mensah & Nabie, 2021).

Understanding gender differences in the context of PowerPoint-based learning environments is crucial for educators and researchers to tailor instructional approaches effectively. While some studies suggest that gender differences can influence cognitive styles and communication strategies during PowerPoint presentations, others indicate no significant disparities. Therefore, there is a need for further research to clarify these inconsistencies and provide more comprehensive insights into how gender influences learning experiences in PowerPoint-based classrooms. Moreover, exploring the relationship between genders and learning motivation in PowerPoint-based learning can offer valuable insights for designing engaging and inclusive instructional strategies.

Understanding whether males or females are more intrinsically or extrinsically motivated in PowerPoint-based learning environments can inform educators about how to enhance student engagement and academic performance. Additionally, as some educators still rely on traditional one-way communication methods with PowerPoint presentations in the classroom, there is a need to investigate how gender differences may impact student participation and interaction in such settings. Through the exploration of gender-specific preferences and perceptions via PowerPoint presentations, it can bring along instructional practices and promote a more collaborative and inclusive learning environment.

2.6.2 Paper-Based Board Games (PBBG)

PBBG has long been a popular form of entertainment and education (Lim et al., 2021). PBBGs have been used in education as interactive and engaging learning tools for decades. Understanding how gender differences play a role in the use and impact of these games is essential for educators and game designers (Eriksson et al., 2021).

Gender disparities may arise due to learning preferences and engagement levels (Salta et al., 2022; Yu, 2021). Gender-based learning preferences can influence academic performance. Males and females might have distinct preferences for visual, auditory, or kinaesthetic learning styles, which can interact with PowerPoint presentation formats (Al Rosjidi & Mohfuroh, 2023; Temiran, 2022; Cabual, 2021; Agu et al., 2021; Nja et al., 2019). In contrast, several previous studies indicated no gender differences while conducting PBBG or similar types of board games in distinct fields (Lin & Hou, 2016; Al-Tarawneh, 2016; Ogunsile & Ogundele, 2016).

Social interaction during board game sessions can highlight gender differences in communication and collaboration (Terlouw et al., 2021). Males and females may display varying social dynamics during group activities facilitated by PBBG (Aurava et al., 2021). The literature underlines how social interaction within board game contexts can influence collaboration patterns (Kuo & Hsu, 2020). Gender differences in taking the lead, facilitating discussions, or assuming cooperative roles are explored.

Understanding whether males or females are more intrinsically or extrinsically motivated when using PBBG can inform tailored teaching strategies (Tan & Nurul-Asna, 2023; Alt, 2023). Learning motivation is closely tied to the relevance and engagement students perceive (Zou et al., 2021).

Undeniably, exploring gender differences in the use and impact of PBBG is crucial for educators and game designers to create inclusive and effective learning experiences. While some studies suggest that gender disparities may arise in learning preferences and engagement levels during PBBG sessions, others indicate no significant differences. Therefore, further research is needed to clarify these inconsistencies and provide deeper insights into how gender influences the use and outcomes of PBBG in education. Furthermore, investigating gender differences in social interaction and collaboration during PBBG sessions can offer valuable insights into how males and females engage with each other in group activities. Understanding these dynamics can inform educators about how to foster inclusive and cooperative learning environments that cater to the diverse needs and preferences of all students. In addition, examining gender-specific motivations for using PBBG can help educators tailor teaching strategies to enhance student engagement and academic performance. By understanding whether males or females are more intrinsically

or extrinsically motivated when using PBBG, educators can design learning experiences that align with students' interests and preferences.

2.6.3 Computerized Board Games (CBG)

In the digital age, CBGs have become increasingly popular (Wang et al., 2022). Understanding how gender differences influence the use and impact of these digital games is essential for educators, game designers, and researchers. Integrating CBG into education is a relatively recent development, reshaping how students interact with learning materials and content (Boghian et al., 2019).

Research indicates that gender differences may manifest in academic performance when using CBG (Wang et al., 2022; Hou & Keng, 2021; Delaney & Devereux, 2021; Vargianniti & Karpouzis, 2020). The design of digital board games can influence how students engage with academic content. Gender-sensitive game mechanics can provide equal opportunities for male and female students. For example, Johnson and Elliott (2020) suggest incorporating competitive and collaborative elements can cater to diverse gender preferences. Aligning game content with academic objectives is critical.

A study by Klimova (2019) found that tailoring content to diverse interests can enhance academic performance. Considering gender-specific content preferences may be beneficial. Brooks and McMullen (2021) suggest that males and females may have distinct goal-setting strategies. Tailoring the goal-setting process to individual preferences can positively affect academic performance. Nevertheless, some previous literature has evidenced no gender differences after implementing CBG or similar types of board games among the participants in respective fields (Li, 2015; Dorji et al., 2015).

For social interaction, the digital nature of CBG can introduce unique gender dynamics in online or computer-mediated interactions (Sousa, 2021). Gender differences in communication styles and collaborative efforts can be observed during group activities. The literature discusses how social interaction within CBG can affect collaborative patterns among male and female students (Chen et al., 2021; Hou & Keng, 2021; Zou et al., 2021; Gabbiadini et al., 2020; Martindale & Weiss, 2020; Poole et al., 2019)

Gender differences may be seen in terms of intrinsic and extrinsic motivation. Understanding which gender tends to be more intrinsically or extrinsically motivated when using CBG is crucial for tailoring teaching strategies. Learning motivation is closely related to how students perceive the relevance and engagement levels of CBG (Wang et al., 2022; Chang & Hwang, 2019). Gender differences can affect students' attitudes towards digital learning tools, including whether they find them engaging and personally relevant.

In summary, understanding the influence of gender differences on the use and impact of CBG is crucial for educators, game designers, and researchers. While some studies suggest gender disparities in academic performance, social interaction, and motivation when using CBG, others indicate no significant differences. Therefore, further research is needed to clarify these inconsistencies and provide deeper insights into how gender influences the use and outcomes of CBG in education. Furthermore, exploring gender-specific preferences in game design and content can enhance the effectiveness of CBG in catering to the diverse needs and preferences of male and female students. Tailoring game mechanics, content, and goal-setting strategies to align with gender preferences can promote equal opportunities and improve academic performance. Additionally, investigating gender dynamics in social interaction within CBG can offer valuable insights into how male and female students engage with each other during group

activities. Understanding these dynamics can inform educators about how to foster inclusive and collaborative learning environments that accommodate diverse communication styles and collaborative efforts. Next, examining gender-specific motivations for using CBG can help educators design teaching strategies that enhance student engagement and academic performance. By understanding which gender tends to be more intrinsically or extrinsically motivated when using CBG, educators can tailor instructional approaches to promote positive attitudes towards digital learning tools.

2.7 Learning Motivation in Science Learning

In the contemporary world, Science plays a vital role in our daily lives, especially in the 21st century. Teachers are pivotal in captivating students' interest and encouraging self-driven explorations in Science Education (Gerard et al., 2022). This is because cultivating interest and motivation is essential to students' engagement and success in learning Science subjects (Kalogiannakis et al., 2021).

The attitudes pupils hold toward Science learning bear immense significance in Science education, as these attitudes closely correlate with their academic achievements (Toma & Greca, 2018). Gonzalez-Gomez et al. (2022) have aptly defined pupils' attitudes toward Science as their emotional responses toward the subject. Conversely, learning motivation is rooted in an intrinsic belief that propels continuous efforts to achieve learning objectives and enhance overall outcomes (Makransky et al., 2019; Asmus, 2021).

The impact of motivation on pupils' Science education cannot be understated. Motivation substantially shapes students' goal-driven action and perseverance in Science education, contributing to their overall success (Yee & Abdul, 2018). Highly motivated

students exhibit a more positive attitude towards learning Science, enhancing their ability to absorb knowledge and develop vital cognitive and critical thinking skills (Stark, 2019). Acknowledging the complexity inherent in attitude and motivation is crucial, as highlighted by Jurado and Garcia (2018). Science educators must recognize the pivotal role of fostering high motivation in students to facilitate knowledge acquisition and improve critical thinking and Science process skills within the classroom setting.

The influence of students' interest and motivation on Science is not limited to their learning experience but extends to positively impacting their academic performance and overall course grades (Yee & Abdul, 2018). Armed with an understanding of motivational principles, instructors possess the tools to amplify students' interest and performance levels in Science. It is worth noting that teachers' instructional methodologies significantly shape students' attitudes and motivation vis-à-vis Science. However, the persistent perception of Science as a dull and challenging subject remains a challenge, potentially hindering students' grasp of Science concepts and impeding effective teaching techniques (Virata & Castro, 2019; Teppo et al., 2021; Windschitil et al., 2020).

However, there are several potential research gaps that could strengthen the review. Firstly, further investigation is needed into the specific instructional methodologies that effectively enhance students' interest and motivation in Science. Understanding which teaching strategies are most successful in cultivating positive attitudes and motivation can inform teacher training and professional development programs. Secondly, exploring the underlying reasons for the persistent perception of Science as a dull and challenging subject among students could provide insights into how to overcome this barrier to effective Science education. Research focusing on students' perceptions of Science, as well as their experiences and interactions within the classroom, could shed light on ways to

make Science learning more engaging and accessible. Moreover, investigating the impact of cultural and societal factors on students' attitudes and motivation toward Science could help educators tailor their approaches to different student demographics. Understanding how cultural beliefs and social norms influence students' perceptions of Science could lead to more inclusive and culturally responsive teaching practices.

2.8 Suggested Theories

2.8.1 Activity Theory (AT)

Activity Theory (AT) is a framework developed by Engeström (2001) that delves into the intricacies of human activity and the social context in which it unfolds. It has undergone three generations of evolution, each building upon the prior one. For this research, the second generation of AT has been chosen as the primary theoretical foundation.

The second generation of Activity Theory revolves around the collective nature of human activities and draws heavily from Engeström's activity systems model. Leont'ev, a key figure in the development of Activity Theory, further refined the activity concept and introduced a hierarchical structure comprising three levels: operations, actions, and activity. Central to this framework is the notion of the Object, which is intricately linked to the goals and motives that drive human activity. In this context, goal-directed actions are transient and individual, while object-oriented activities are enduring and collective (Karanasios, 2018)

Leont'ev (1981) enriched the activity model by introducing three interconnected levels: activity, action, and operation. This model places particular emphasis on the process

of transforming social activity into cognitive structures internalized at the individual level. At its core lies the object or motive that underpins human activity. Operations constitute the fundamental activity level, while actions occupy the subsequent tier. Conscious actions are tied to individual skills and knowledge, crucial in planning individual and collective activities. Finally, the highest echelon of the activity hierarchy encompasses goals and motives. This second generation of Activity Theory offers a robust framework for understanding the complex interplay between individuals, their activities, and the broader social context. Its emphasis on the collective nature of activities and the role of objectives and motives provides a comprehensive lens through which researchers and practitioners can analyze and enhance various aspects of human behaviour and cognition.

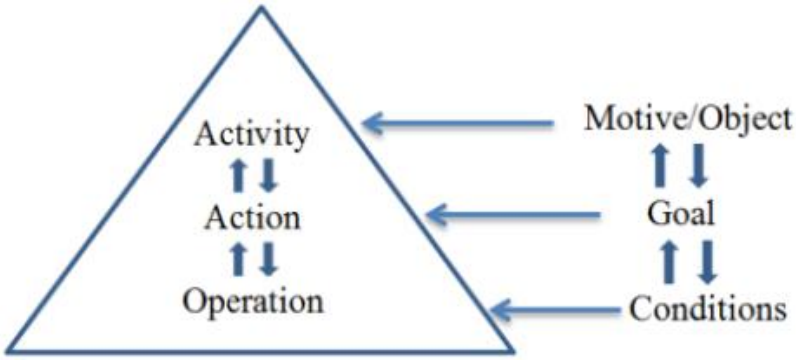


Figure 2.1: Hierarchical Levels of an Activity (Leont've, 1981)

Figure 2.1 illustrates the dynamic continuum of human activity through its three levels. The first level centres on planned motives, probing the underlying reasons driving an endeavour. Here, the focus is on the 'why' behind a particular pursuit. The second tier encompasses conscious actions, representing tangible accomplishments and outcomes of the activity. This level delves into the 'what' – the visible results stemming from the initial motives. Descending to the third level, we encounter operations, which spotlight the 'how'

aspect of achievement. This stratum delves into the methodologies, techniques, and strategies to achieve the goals. Each level plays a pivotal role in unravelling the intricate fabric of human activities, offering a comprehensive understanding of the underlying mechanisms.

Activities are not static but undergo dynamic transformations, often encompassing multiple phases. A symbiotic relationship takes shape between the subject (the individual partaking in the activity) and the object (the goal or purpose that propels the action). This interplay leads to internalization, wherein the activity becomes an integral part of the individual's cognitive landscape.

As practices are honed and internalized through repetition, the evolution from mere actions to more automated operations occurs. This progression, documented by scholars such as Blayone (2019), Karanasios (2018), and Karanasios et al. (2021), is marked by a gradual reduction in conscious effort as operations become second nature.

Engestrom's assertion in 1987 underscores the value of AT as a reservoir of analytical tools aptly suited for dissecting and modelling activity systems. Figure 2.2 encapsulates the foundational structure of AT, meticulously chosen as the bedrock of this research. This figure epitomizes the theoretical framework for comprehending the intricate interplay of motivations, actions, and operations within human activities.

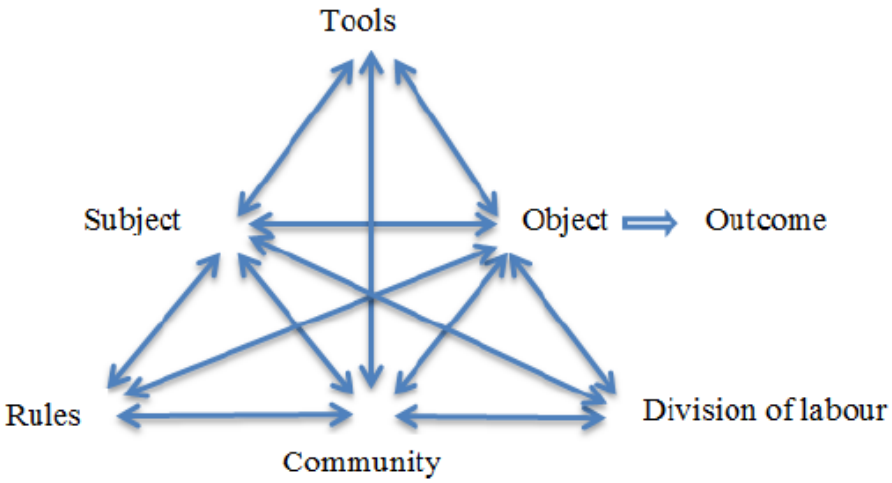


Figure 2.2: Engestrom's Expanded Activity Theory Model (Engestrom, 1987)

Engestrom's expanded AT, illustrated in Figure 2.2, introduces mediators such as tools, rules, community, and division of labour. These mediators play a pivotal role in facilitating relationships between the elements of activity systems. Tools, for instance, mediate between the subject and object, while rules mediate between the subject and community.

Marwan and Sweeney (2019) proposed that meaningful activity systems, essential for understanding human activities, should encompass fundamental elements. This concept holds particular relevance within the educational sphere, where activity systems can be established within classrooms or entire schools. Learning processes can transcend individual boundaries and find resonance within sociocultural contexts by embracing a broader perspective (Bower, 2019).

AT postulates contradictions, as it can act as hindrances, are such as obstacles, interruptions, conflicts, as well as gaps and catalysts within activity systems. In this research, introducing new technology to 10-year-old participants resulted in tension and

frustration, leading to what Engeström (2001) terms "expansive transformation." This transformation involved reconceptualizing the object and motive of the activity to embrace a wider range of possibilities beyond the confines of the previous mode of engagement.

AT provides a comprehensive framework for understanding human activities within their social context, offering insights into the dynamics of both PBBG and CBG. According to Leont'ev's model, activities consist of three interconnected levels: activity, action, and operation. In the context of board games, the activity level represents the overarching goal or purpose of playing the game. Actions encompass the tangible moves and decisions made by players during gameplay, while operations involve the specific strategies and techniques employed to achieve those actions. This hierarchical structure allows researchers to analyze the cognitive processes and social interactions involved in playing board games at different levels of granularity. Through repeated practice and engagement with board games, players internalize the rules, strategies, and norms associated with gameplay. Initially conscious actions gradually become automated operations as players become more proficient in the game. This process of internalization reflects the dynamic nature of human activities and highlights the role of experience and skill development in shaping gameplay behaviours. Engeström's expanded AT introduces mediators such as tools (e.g., game pieces, boards) and rules (e.g., game rules, social norms) that mediate between the subject (players) and object (goals of gameplay). In the context of board games, these mediators facilitate interactions between players and the game environment, influencing strategic decisions, communication patterns, and social dynamics during gameplay. AT recognizes contradictions within activity systems as both hindrances and catalysts for change. Introducing new technology or game mechanics to board games may initially create tension and frustration among players, but it can also lead

to expansive transformations in gameplay dynamics and objectives. By reconceptualizing the object and motive of the activity, players may adapt their strategies and behaviours to embrace new possibilities and modes of engagement.

2.8.2 Social Constructivism Theory (SCT)

SCT integrates knowledge from sociology and communication to develop understanding and meaning in the world. According to Ramadhan (2022), human beings construct their social reality and functions by rationalizing their experiences, with language serving as the primary system for constructing human reality.

In social constructivism, individuals and groups engage and socialize within a social system, with mental representations of each other's actions becoming ingrained in daily habits (Ravanis et al., 2018). In this process, society members with distinct roles institutionalize reciprocal interactions.

Vygotsky (1978) posits that cognitive growth takes root in a social setting and can also unfold within individuals. Constructing knowledge within a social context enables learners to connect with their environment (Knapp, 2019). Vygotsky emphasizes that knowledge and skills are developed through interactions before being internalized.

Social constructivism is based on three main assumptions: reality, knowledge, and learning. These assumptions assert that reality is constructed through human activity, existing as a social creation rather than an absolute truth. Knowledge is conceived as a human creation shaped by social and cultural dynamics, with individuals creating meaning through interactions and communication. Learning is also viewed as a social process where

meaningful learning emerges through active participation in specific social activities rather than passively developing behaviours shaped by external influences.

Social constructivists focus on two main aspects of the social context that influence learning: symbol systems, such as language and logic, which dictate what is learned, and the learner's social interaction with knowledgeable members of society. For young children, the cultivation of cognitive faculties occurs through communication with more knowledgeable individuals, as social interaction plays a crucial role in understanding the social implications of crucial symbol systems.

SCT emphasizes the culture and the social context in cognitive development. Learning is seen as a process of enculturation and social interactions within a community of practices. Lev Vygotsky challenged the notion that cognitive development is primarily an individual endeavour, championing collaboration as a crucial facet of learning (Lameras & Arnab, 2021).

A cornerstone of Vygotsky's framework is the Zone of Proximal Development (ZPD), introduced to address challenges in educational psychology, such as assessing a child's intellectual abilities and evaluating instructional practices. The ZPD represents the pace between a child's current developmental level and their potential for higher development with guidance from educators or peers. Learning within the ZPD involves interactions with others, catalyzing internal developmental processes (Silalahi, 2019). Instruction and development intertwine in a nuanced relationship (Polly & Byker, 2020).

Picciano (2021) identifies four perspectives for facilitating learning within the social constructivism framework. The first perspective underscores cognitive tools for acquiring cognitive skills and strategies, encompassing hands-on project-based techniques

and discipline-based cognitive tools. The second perspective spotlights idea-based social constructivism, prioritizing fundamental interdisciplinary concepts to expand students' horizons and shape social understanding.

As one facet of social constructivism, the pragmatic or emergent approach entails classroom implementation as needed (Gravemeijer, 2020). The second perspective, idea-based social constructivism, accentuates essential multidisciplinary concepts (Chu et al., 2019). The third perspective, the transactional or situated cognitive approach, underscores the relationship between students and their environment (Maree et al., 2018). Indeed, social relationships and the classroom environment profoundly influence learning.

According to SCT, cognitive growth occurs through social interactions within a community of practices. In the context of board games, players engage in collaborative problem-solving, strategic decision-making, and rule negotiation, all of which contribute to their cognitive development. Whether playing PBBG or CBG, players construct knowledge and meaning through their interactions with others, leveraging language and symbolic systems to communicate and navigate the game environment. Vygotsky's ZPD concept is particularly relevant to understanding learning dynamics in board games. The ZPD represents the gap between a player's current abilities and their potential for higher development with guidance from more knowledgeable peers or educators. Within the context of board games, players operate within their ZPD as they engage in gameplay, receiving feedback, guidance, and support from fellow players. Whether playing PBBG or CBG, players collaborate and scaffold each other's learning within their ZPD, leading to cognitive growth and skill acquisition. SCT offers various perspectives for facilitating learning within the context of board games. Cognitive tools, such as hands-on project-based techniques and discipline-based cognitive tools help players acquire cognitive skills

and strategies while playing board games. Idea-based social constructivism emphasizes interdisciplinary concepts embedded within board game mechanics, expanding players' understanding and fostering social awareness. The transactional or situated cognitive approach highlights the importance of the classroom environment and social relationships in shaping learning experiences. Whether implementing emergent classroom practices or emphasizing multidisciplinary concepts, SCT provides valuable insights into designing effective board game-based learning experiences. Then, SCT emphasizes the role of symbol systems, such as language and logic, in shaping what is learned within social interactions. Whether playing PBBG or CBG, players engage with symbolic representations embedded within the game mechanics, communicating and negotiating meanings with other players. These interactions facilitate knowledge construction and meaning-making, highlighting the cultural and social dimensions of board game play.

2.9 Theoretical Framework

Drawing from the concerns delineated in this research, several components come into play within these two theories, AT and SCT, encompassing academic performance in Year 4 Science, learning motivation, and social interaction. The ensuing theoretical framework serves as a means to converge these theories into a visual representation showcasing the efficacy of PBBG and CBG within the CL approach in Year 4 Science learning.

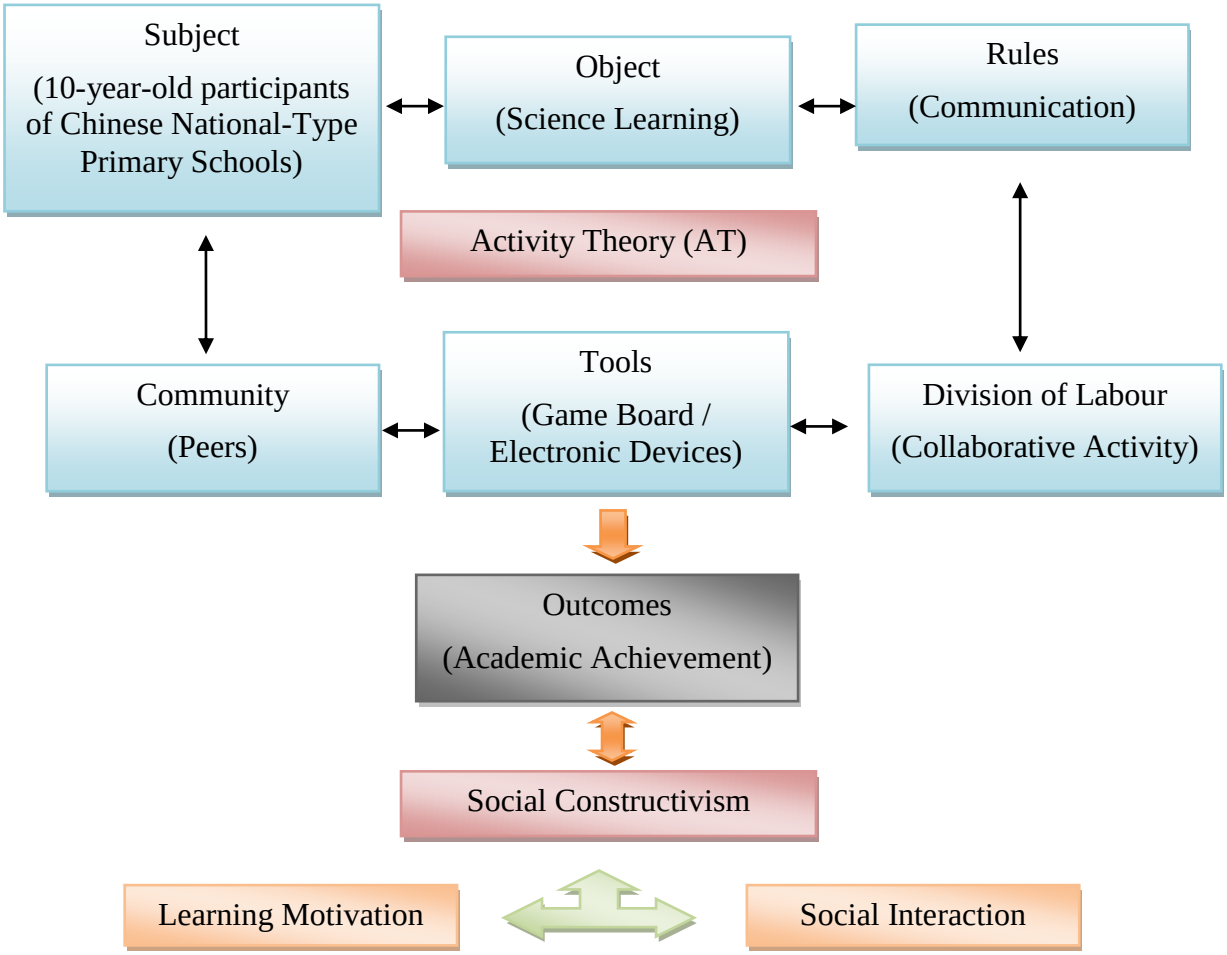


Figure 2.3: Proposed Theoretical Framework of General Concepts

Based on Figure 2.3, Engestrom's expanded AT incorporates mediators such as Tools (game board or electronic device), Rules (communication etiquette), Community (peers), and Division of labour. These mediators facilitate relationships between the Subject (10-year-old participants) and Object (Science learning) and interactions among the participants during PBBG and CBG implementation, with CL in the classroom.

Furthermore, AT underscores how contradictions can act as obstacles, interruptions, conflicts, and gaps yet fuel activity system development. In this research, introducing new technology to 10-year-old participants initially generated tension and

frustration when they grappled with the proper usage of electronic devices. This led to an "expansive transformation," where the activity object and motive were reconceptualized to embrace new possibilities compared to the previous mode of activity or engagement.

The theoretical framework of this research focused on the Science education activity of 10-year-old participants. The objective was to foster collaborative face-to-face group discussions, where participants shared insights using mobile devices like iPads or phones. The subject, represented by the 10-year-old participants from National-Type for Chinese Primary Schools, actively engaged in these group discussions. Rules and regulations were set to ensure effective cooperation within small groups for obtaining answers during the discussions. The dynamics of cultural norms governed the participants' interactions and collaborative activities in the Science classroom.

The division of labour in this research involved the researcher (teacher) responsible for organizing the activity infrastructure based on selected Year 4 Science topics. The 10-year-old National-Type for Chinese Primary Schools participants actively engaged in collaborative activities within the specified period. The community comprised the researcher and participants, all working towards improving Science learning performance for the 10-year-old participants.

The socio-cultural perspective of mobile learning aligns with pedagogical approaches advocated by researchers like Prestigiacomo (2022) and Okai-Ugbaje et al. (2022). CL is recommended to foster collective knowledge development among 10-year-old participants, impacting learning motivation and maximizing the benefits of learning tools and electronic devices in CBG. Through participant interaction and communication,

Science learning becomes a social endeavour mediated by PBBG (game board) and CBG (electronic devices).

The social context was integrated into using PBBG and CBG to promote relationships and activity stability among 10-year-old participants from National-Type Chinese Primary Schools. These participants shared a common objective to prevent confusion and collaboration using PBBG and CBG with CL in the Science classroom. Individual tasks were completed to achieve group goals, and group activity tasks were conducted with tasks like interchange, construction, and management were completed. Encouragement of communication and sharing comments and answers within the group aimed to achieve the best and most accurate answer during lessons.

Each participant in the group played a social role, considering others' opinions to work towards a unified goal. Social rules ensured the selection of the most acceptable answer in case of disagreements. Technology roles involved collaborative task assignment, question formation, and mediation through game boards and electronic devices (PBBG and CBG). The tools provided a negotiation space for each group member to arrive at the finalized answer during the Science teaching and learning process in the classroom.

2.10 Summary

This chapter lays the foundation by highlighting the potential impact of physical and digital board games on teaching and learning, drawing on insights from previous research. However, implementing PBBG and CBG within CL for Science education among 10-year-old participants in National-Type Chinese Primary Schools remains an underexplored area. The present study aims to address this gap by assessing the

effectiveness of CT, PBBG, and CBG, combined with CL in enhancing Science learning outcomes, learning motivation, and social interaction among 10-year-old participants in National-Type Chinese Primary Schools located in Sibu, Sarawak. The following chapter will delve into a comprehensive exposition of the intricate design and development of PBBG and CBG, with CL.

CHAPTER 3

DESIGN AND DEVELOPMENT

3.1 Introduction

This chapter discusses AGILE system development, as this instructional design model has been selected to design and develop the PBBG and CBG, with CL. A brief explanation of this system development is demonstrated, followed by the design and development of board games, namely, PBBG and CBG, with CL. It also elaborates on playtesting and results for board games, as well as the possible changes, improvements and further development opportunities for the future.

3.2 AGILE System Development

3.2.1 Definition

AGILE is a software development methodology that anticipates the need for flexibility and applies pragmatism to deliver the finished product. It encompasses five stages in designing e-learning experiences, represented by the acronym AGILE: Align, Gets set, iterate and implement, Leverage and Evaluate (Drysdale, 2019). In this research, the finished products are PBBG and CBG, with CL. AGILE system development requires a cultural shift in many settings. For instance, this research focuses on delivering individual pieces or parts of the software (Kula et al., 2021) rather than the entire application of both versions of board games, PBBG and CBG. AGILE system development defines a set of values to explore new and improved ways of developing software (Zorzetti et al., 2022). Four key principles have been deduced: (1) prioritizing individuals and

interactions over processes and tools; (2) valuing working software over comprehensive documentation; (3) emphasising customer collaboration over contract negotiation; and (4) favouring responding to change over following a rigid plan (Jirapanthong, 2021).

The primary emphasis of AGILE system development is to attain organisational, personal, and technical success by embracing methods that align with its philosophy. Various sources present differing definitions of AGILE, a point substantiated by Moniruzzaman and Hossain (2013), "*An iterative and incremental approach to software development which is performed in a highly collaborative manner by self-organising teams within an effective governance framework with "just enough" ceremony that produces high-quality software in a cost-effective and timely manner which meets the changing needs of its stakeholders*". AGILE system development follows iterative processes, encompassing shorter deadlines, continuous evaluations (Austin & Devin, 2009), self-organising cross-functional teams, and decentralised decision-making power over the team's agenda and focus. The self-organising teams frequently meet and derive decisions and feedback from informal communication (Barlow et al., 2011).

Four core values have to be emphasised in AGILE system development. The first core value is that "Individual interactions are more important than processes and tools" (Zasa et al., 2020). In this context, it becomes imperative for game designers or individuals responsible for game development, such as board games, to steer the development process. This approach ensures responsiveness to the requirements and needs of game stakeholders or customers, who hold the utmost significance in the development process and should take precedence over processes and tools.

Conversely, if the development of a game, including board games, is driven primarily by the processes or tools, the game designers or those creating the games may

become less adaptable to change (Storme et al., 2020). Consequently, they might be inclined to meet the needs of stakeholders, who, in the case of this research, were 10-year-old participants from National-Type Chinese Primary Schools.

The second core value of AGILE system development is "A focus on working software rather than thorough documentation" (Mergel et al., 2021). Before adopting AGILE, it became evident that a substantial amount of time was spent documenting the product throughout the development process, leading to extensive lists of documented requirements and significant delays (Stirbu & Mikkonen, 2020). To address this, it is crucial to streamline the documentation process, providing game designers or those involved in game development with only the necessary information, such as user stories.

The third core value is "Collaboration instead of contract negotiations" (Anjum & Wolff, 2020). AGILE highlights the significance of collaboration between the customer and project manager, especially relevant to this research involving 10-year-old participants and the researcher, instead of focusing on negotiations between these parties (Khovrat & Teslenko, 2022). This collaborative approach facilitates the detailed planning of product delivery, namely, PBBG and CBG. Moreover, involving customers in the collaboration process ensures continuous engagement throughout the development cycle rather than just at the outset and conclusion. In this research, for instance, the customer (10-year-old participants) can participate at various intervals for product demonstrations (PBBG and CBG) within the AGILE system development framework. Nevertheless, it is undeniable that the products must ultimately align with the stakeholders' desires upon release.

The fourth core value of AGILE system development is "A focus on responding to change" (Janssen & Van der Voort, 2020). Traditionally, change has often been avoided in software development due to its perceived costliness. AGILE challenges this notion by

embracing change, facilitated by its short iterations, which enable modifications to be easily integrated into the development process to better cater to stakeholders' needs (Gheorghe et al., 2020). Consequently, AGILE system development believes that change is pivotal to enhancing the design and development of final products (Al-Saqqa et al., 2020), including board games, adding value for stakeholders.

AGILE methodology anticipates the need for flexibility and pragmatism in delivering the finished product. In educational content creation, particularly in designing PBBG and CBG, flexibility is essential to accommodate the evolving needs and preferences of learners. AGILE allows for iterative development cycles, enabling educators and game designers to respond quickly to feedback and incorporate changes to better meet the educational objectives. AGILE prioritizes customer collaboration over contract negotiation. In the context of educational content creation, stakeholders include learners, educators, and instructional designers. By involving these stakeholders throughout the development process, AGILE ensures that the final product aligns with their needs and expectations. For example, educators can provide valuable insights into learning objectives and pedagogical approaches, while learners can offer feedback on game mechanics and engagement.

Furthermore, AGILE emphasizes iterative and incremental development, focusing on delivering working software rather than extensive documentation. Similarly, in educational content creation, focusing on developing tangible learning experiences, such as playable prototypes of PBBG and CBG, allows for early testing and validation of learning outcomes. This iterative approach enables educators to refine and improve educational content based on real-world usage and feedback. AGILE promotes responsiveness to change, recognizing that educational needs and requirements may evolve over time. By

adopting AGILE principles, educational content creators can effectively manage change by incorporating updates and enhancements to PBBG and CBG during development cycles. This agility ensures that educational content remains relevant and impactful in addressing learners' needs and adapting to emerging educational trends.

AGILE prioritizes individual interactions and collaboration over processes and tools. In educational content creation, this translates to a focus on designing learning experiences that foster active engagement, collaboration, and meaningful interactions among learners. By aligning educational content with AGILE principles, educators can create immersive and interactive learning experiences that promote critical thinking, problem-solving, and knowledge acquisition. Overall, the application of AGILE principles to educational content creation offers a structured and iterative approach to designing engaging and effective learning experiences, such as PBBG and CBG.

3.2.2 The 12 Principles of AGILE System Development

The AGILE system development has 12 main principles for the development process nowadays (Mukhamadjonov & Kasim, 2017). They are:

P1: Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.

For this principle, the researcher has to ensure that the users, particularly the 10-year-old participants of this research, were happy when they received the board games and played them at regular intervals rather than waiting long periods between releases (Gheorghe et al., 2020).

P2: Welcome changing requirements, even later in development

Undeniably, the AGILE process harnesses the change for the customer's competitive advantage (Kakar, 2023), especially as it is recommended for the research participants to enhance their board game-playing experience. Adapting swiftly to changing requirements or feature requests becomes crucial in this research. Consequently, the researcher iterates over specific sub-projects, such as the PBBG and CBG in this case, and post-release modifies the plan based on fresh insights gained during the process. With the researcher actively involved in this research, adding new features to the products, PBBG and CBG, should not pose significant challenges during the design and development of the board games (Reichwein et al., 2020).

P3: Deliver working software frequently, from a couple of weeks to a few months, with a preference for a shorter timescale.

The P3 principle extends from the first principle, necessitating frequent deliveries due to the requirement for iterations to conclude within specific timeframes. Consequently, the duration is determined by the game designers or individuals involved in designing and developing the games, along with the challenges encountered by the project.

P4: Business people and developers must work together daily throughout the project.

Daily meetings are essential for effective project development, ensuring the exchange of information regarding progress. Optimal decisions are reached through alignment between business and technical teams (Horlach et al., 2020). However, in this research, only the researcher was involved in designing and developing the board games. Consequently, since no collaborative meetings occur, the researcher has maintained a

systematic record of information and progress updates for the design and development of PBBG and CBG.

P5: Build projects around motivated individuals.

The P5 principle, which involves motivated individuals to meet project deadlines, is important. However, it is worth noting that in this scenario, the researcher was the sole contributor involved in designing and developing both board game versions, PBBG and CBG. This concentrated involvement heightened the likelihood of delivering optimal results, as a motivated environment and robust support were cultivated to achieve the objectives in board game design and development within this research.

P6: A face-to-face conversation is the most efficient and effective method of conveying information to and within a development team.

The P6 principle was formulated before the widespread prevalence of geographically dispersed teams (Stendal et al., 2022). However, in the context of this research, the design and development of the board games—namely PBBG and CBG—were undertaken solely by the researcher. The researcher was responsible for ensuring the effective utilisation of collected information. Subsequently, the creation of these board games was centred on meeting the needs and preferences of the intended users, specifically 10-year-old participants from National-Type Chinese Primary Schools.

P7: Working software is the primary measure of progress.

Given this, delivering functional software to the project's users, exemplified by PBBG and CBG in this research, is the ultimate factor that measures progress. For the researcher, guaranteeing progress entails delivering operational and gratifying iterations of both board game versions, subsequently augmented by additional features. This holistic

approach aims to cultivate an environment conducive to design and development within the Science classroom.

P8: Agile processes promote sustainable development

The P8 principle dictates that both the game designers responsible for the design and development of the board games and the users (10-year-old participants from National-Type Chinese Primary Schools) should sustain a consistent pace over time. This entails establishing a repeatable and maintainable speed to deliver functional software with each release consistently. A pivotal component of this principle is the regular release of products for ongoing review and feedback, facilitating continuous improvement and adaptation.

P9: Continuous attention to technical excellence and good design enhances agility.

It is important to pay close attention to technical excellence and design as the product evolves (Zayat & Senvar, 2020), particularly for PBBG and CBG in this research. Striking a balance between "Building the right thing" and "Building the thing right" for the design and development of a certain product (Begnum et al., 2021), including the board games tailored for the use of 10-year-old participants in the Science classroom. Consequently, the researcher must diligently conduct testing to ensure the ongoing functionality of both board games' design and development. In doing so, the right skill set and effective design principles maintain a consistent pace and facilitate continuous improvement and adaptation of the product (Gheorghe et al., 2020).

P10: Simplicity

The next principle of AGILE system development is simplicity, emphasising maximising efficiency in designing and developing board games for this research (Narayanan, 2021). AGILE revolves around striking the right workload balance at any

given time (Welfen et al., 2022), with the researcher tasked with developing user stories appropriately and ensuring effective task completion (Gheorghe et al., 2020). Prioritizing the construction of necessary elements is pivotal, avoiding the creation of an overly intricate framework solely to accommodate the requirements of designing and developing the board games (Kasauli et al., 2021), encompassing PBBG and CBG, in the interest of the learners—specifically, the participants in this research.

P11: the best architectures, requirements, and designs emerge from self-organising teams.

In this context, it becomes imperative for the researcher or educators from the MOE to grasp the most suitable approach for achieving teaching and learning objectives. However, this does not imply that the desired outcomes will naturally materialise, as each learner's stage of personal development in Science learning varies (López-Alcarria et al., 2019). Consequently, the term "game designer" emerged within the AGILE system development framework, replacing the conventional command-and-control project manager role (Fischer & Charef, 2021). As the board game designer in this research, the researcher must possess both skill and motivation. This entails maintaining regular communication with school educators to facilitate the exchange of ideas, ultimately contributing to creating high-quality final products—specifically, PBBG and CBG.

P12: At regular intervals, the team reflects on becoming more effective, then tunes and adjusts its behaviour accordingly.

In this research, it is important to ensure that the board game designers or the researcher who aims to improve the learners' teaching and learning performance possess self-improvement, process improvement, and advancing skills and techniques to make work more efficient (Daoudi et al., 2020). Undoubtedly, the interrelation of each AGILE

principle is vital in this research, as the researcher may encounter challenges while engaging in genuine self-reflection during the design and development of PBBG and CBG, with CL in Science learning.

3.2.3 Benefits of AGILE Development

In discussing the benefits of AGILE development, Sutherland & Schwaber (2010) posited that it could 1) accelerate the pace of development, 2) align individual and corporate objectives, 3) foster a performance-driven culture, 4) support value creation for shareholders, 5) ensuring stable and consistent communication of performance across all levels, and 6) enhancing individual development and quality of life. These attributes must be interlinked and correlated, including external factors beyond the scope of the AGILE development method (Steiber et al., 2021). However, AGILE development can enhance development and reach users faster. There must be mechanisms to collect user feedback and needs, transform them into knowledge, and develop functional solutions that meet the stakeholders' requirements (Anad & Dinakaran, 2015).

Consequently, the desired products, PBBG and CBG, emerge as a response to the desired stakeholders' needs, particularly the participants. These products drive value creation and could be seen as mechanisms that enable game designers or those shaping the board games to process stakeholder information, ultimately guiding the creation of the most fitting products.

This context also harmonises with the alignment of individuals (Dumitriu et al., 2019), notably the game designers or those crafting the board games for this research, striving to attain objectives. Strong governance is imperative to ensure that closely

collaborating teams avoid working in isolation (Misra et al., 2009). On the other hand, prioritizing superior outcomes is vital. Successfully designed and developed final products, such as PBBG and CBG, contribute to stakeholder enjoyment, as evidenced by the acceptance of both games by the majority of 10-year-old participants currently attending National-Type Chinese Primary Schools in this research.

3.2.4 Framework for AGILE Development

Undeniably, several different methods support the AGILE, such as Scrum (Schwaber & Sutherland, 2021), Scaled AGILE Framework (Stelzmann, 2012), Lean Software Development (Poppendieck, 2012), Dynamic Systems Development Method (Voigt et al., 2004), Extreme Programming (Akhtar et al., 2022), AGILE Modeling (Romano & da Cunha, 2019) and Adaptive Software Development (Kumar et al., 2019). However, the AGILE Life Cycle Instructional Design method has been adopted for this research to orchestrate the design and development of board games, specifically PBBG and CBG.

The AGILE methodology is the approach which focuses on people, customer collaboration and software interaction rather than focusing on plans, processes, and tools (Shaikh & Abro, 2019). The AGILE methodology yields several models, one of which is the Spiral Model (Hema et al., 2020), developed by Boehm (1986), and is the chosen model for this research. This AGILE methodology model is essentially a blend of the Waterfall Model and the Unified Model (Kirpitsas & Pachidis, 2022), with a central focus on product risk management (Esteki et al., 2020), specifically applicable to PBBG and CBG in this research. This model was selected due to its incorporation of phases and

iterations, drawing from the unified process concept, and simultaneous inclusion of sequential repetition inspired by the waterfall model.

Furthermore, each phase has been exemplified by a subsequent iteration. At the end of the initial iteration, a preliminary version of the product is prepared, and customer feedback is requested and assessed (Akhtar et al., 2022). In this research, PBBG and CBG were released in the first iteration. Subsequently, feedback from experienced educators was sought and analyzed for the second iteration. Commencing from this point in the second iteration, and considering prior input, an alternative version of PBBG and CBG was unveiled.

Moreover, this model is inherently oriented toward risk management. Its iterative cycles facilitate the easy identification and resolution of potential risks (Gouthaman & Sankaranarayanan, 2021), while a specific sequential model—such as the waterfall model—can be adopted for development purposes whenever required (Awad, 2005; Munassar & Govardhan, 2010; Aitken & Ilango, 2013). This research has also incorporated the AGILE methodology, specifically the Spiral Model, into the AGILE life cycle instructional design (Unger & Novak, 2011), as shown in Figure 3.1.

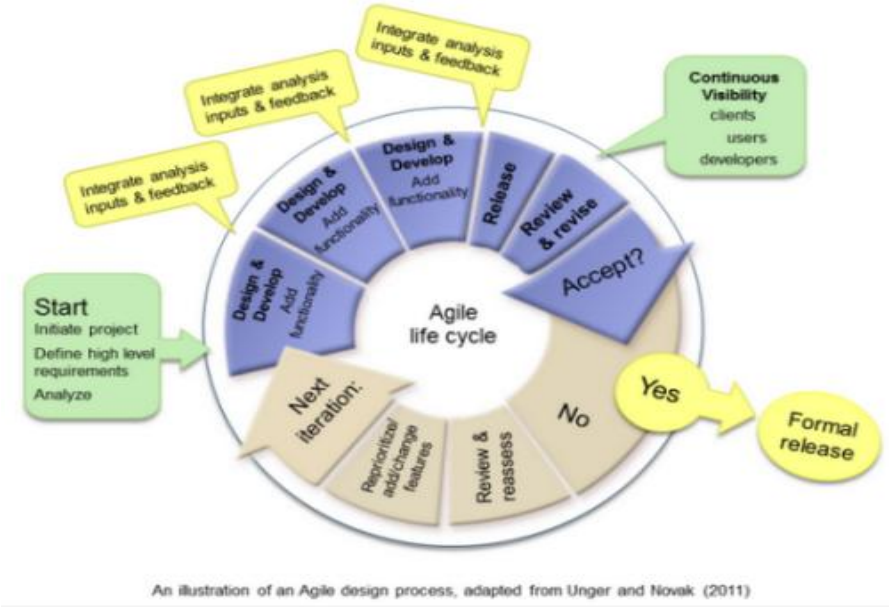


Figure 3.1: Adapted AGILE Design Process from Unger & Novak (2011)

The AGILE instructional design model has been adapted to encompass foundational principles drawn from established iterative and incremental approaches (Neumann & Baumann, 2021). By incorporating the human reality factor to achieve a greater result, the researcher should embrace product development for educational purposes, fostering innovation and change within the learning process. Thus, this research focused on designing and developing board games, specifically PBBG and CBG, tailored to align with the learning objectives of National-Type Chinese Primary Schools' Year 4 Science syllabus. Moreover, its innovative aspect integrates CL, representing a transformative shift from traditional teaching methods to student- and material-centred learning approaches.

Due to the success of the AGILE life cycle instructional design, the method rapidly gained traction and was embraced by specific participants within Science classroom settings (Gheorghe et al., 2020). Consequently, the responsibility for designing and

developing the board games rested solely with the researcher, who navigated the iterative and incremental process, as illustrated in Figure 3.1 (Budoya et al., 2019). In this capacity, the researcher was tasked with assuming multiple roles, as outlined in the adapted AGILE life cycle instructional design by Unger & Novak (2011). These roles encompassed product development, demonstrating requisite skills for the task, and active involvement in envisioning the final product.

Figure 3.1 depicts several key steps within the AGILE life cycle process that demand careful attention from the researcher during the design and development of PBBG and CBG within the Science classroom. However, it is important to note that not all steps necessitate acceleration; rather, they call for a reasonable balance of speed and flexibility to yield optimal outcomes. The articulation of the product's vision, particularly concerning PBBG and CBG, was based on the research questions. These inquiries centred on three primary facets: academic performance, social interaction, and learning motivation among 10-year-old participants in the Science classroom. This listing represents a prioritized and sequenced compilation of activities structured according to user preferences and aligned with the business value of Science learning (Arefazar et al., 2022).

The researcher was responsible for continuously adding and removing items and reprioritizing the list while implementing the AGILE life cycle instructional design (Nazir, 2020). Each part of the cycle indicates different works in designing and developing the board games, such as initiating the project, followed by defining high-level requirements and analysis (Budoya et al., 2019). This life cycle was extended by incorporating additional functionalities, integrating inputs and analysing participant feedback, and a process was conducted until the final release (de Vicente Mohino et al., 2019). First, the researcher initiated the design and development of board games. Subsequently, integrating

inputs and analysing participant feedback was conducted until both versions of board games were released for further action. After the release, it is time to review and revise, as the researcher should focus on the users' continuous visibility. The researcher conducted a formal release once the participants accepted those board games during the development (Islam & Storer, 2020). If many participants did not accept the board games, the researcher must review and re-assess them. These board games were reprioritized as those features were added or changed. Then, the next iteration was conducted as the researcher tended to add functionality to both board games until they were accepted by most participants and resulted in a formal release (Subih et al., 2019).

3.3 Design and Development of Board Games

In this research, two versions of board games were developed to determine the effectiveness towards 10-year-old participants' academic performance, social interaction features and learning motivation in Science learning. Hence, the researcher focused on designing and developing PBBG and CBG.

3.3.1 Paper-Based Board Games (PBBG)

Based on the adapted AGILE life cycle instructional design by Unger and Novak (2011), the researcher initiated the project by focusing on the problems commonly faced by the participants currently studying at National-Type Chinese Primary Schools, particularly in the Science classroom. The 10-year-old participants were involved in this research, as their academic achievement, social interaction and learning motivation in Science learning were investigated. The high-level requirement was the researcher's decision to focus on

gamification in Science education. Undeniably, various gamification examples have been implemented in the learning process, such as card games, video games, board games and others. However, a board game was specifically selected and integrated into this research, as it fulfilled the requirements, particularly fostering social interaction and enhancing learning motivation among the research participants. This facilitated collaborative engagement with others while learning new knowledge from the Year 4 Science syllabus, as emphasized by MOE at all National-Type Chinese Primary Schools.

Board games utilized graphical symbols, often illustrated on a sturdy board, as a medium for user interaction and recording. Beyond the fundamental game board, diverse accessories are essential for gameplay, encompassing chess pieces, dice, chips, cards, tokens, and scorekeeping columns. Sometimes, a board game may be called a tabletop or computerised game. The researcher analyzed the concept of the commercial board game, namely, "Millionaire Monopoly Game", to pave the way for developing an innovative educational board game tailored to Science learning for 10-year-old participants in this research. This educational board game, PBBG with CL, aligned with the research objectives. Furthermore, an evaluation of the rules and regulations governing the "Millionaire Monopoly Game" was undertaken, enabling the researcher to subsequently adapt and modify them to shape the instructions for PBBG in this research. The original rules and regulations for playing the "Millionaire Monopoly Game" are:

1) Preparation

The chessboard is crafted from cardboard, providing a level and smooth surface. The destiny paper cards are positioned across the board, face down. Each player selects a representative object and receives a set of banknotes. The bank manages the remaining funds, and players may also be bankers.

2) Dice

Initially, each player rolls the dice separately. Subsequently, the dice are rolled, and players advance following the points rolled. Actions are then taken as prescribed by the regulations. The player must be jailed if the dice yield the same number of points three consecutive times.

3) Salary

Players can get a salary from the bank every time they pass the starting point.

4) Stay

Upon stopping at a certain location, the player must answer the questions provided by the banker. If the player provides a correct answer, the banker must reimburse the player per the question's value; conversely, if the response is incorrect, the player may owe the banker the corresponding sum.

5) "Fate" and "Chance"

When the player reaches "Fate" or "Chance" space, the player is tasked to draw a paper card and respond to the question presented.

6) Income Tax

Household tax and personal income tax shall be paid to the bank.

7) Into Prison

Two scenarios may occur: (1) if the player lands on the "Go to Prison" space, they must move their representative piece to the designated prison area, suspending forward movement for three rounds. During this time, the player is ineligible for bonuses. (2) If the

player rolls the dice and obtains the same number three consecutive times, they must immediately enter the Prison under similar conditions as described in scenario (1).

8) Out of Prison

The imprisoned player will be released in one of the following situations. (1) If the dice' combined number is 12. (2) Alternatively, they can pay a fine of RM1000 for a release before the next turn after entering the Prison.

9) Be a winner

The player earning the most banknotes within the allotted time is the winner.

The next AGILE life cycle instructional design phase is "Design and Develop: Add Functionality". During this stage, the researcher integrates the inputs and analyzes the feedback adapting the "Millionaire Monopoly Game" into an educational version of the board game, referred to as the "*SciFun* Board Game" or PBBG in this research. The researcher named PBBG a "*SciFun* board game" because it is important to incorporate the game element into the Science learning process since the research participants can play and learn new knowledge simultaneously.

Following the AGILE life cycle instructional design, the researcher aimed to create PBBG by manually drawing it, as illustrated in **Figure 3.2**.

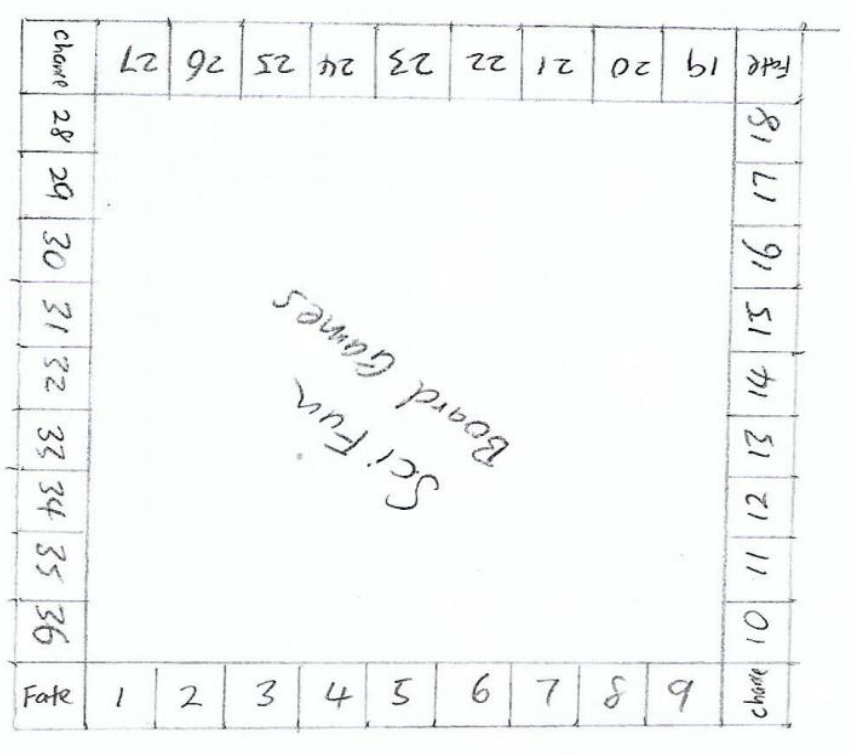


Figure 3.2: Prototype for First Draft of PBBG "*SciFun* Board Game"

As illustrated in Figure 3.2, the board game was divided into four sides, each comprising nine subsections, with an additional subsection at each corner. Sequential numbers were assigned to each subsection, beginning with "1" and concluding with "9" for the first side, followed by the "Fate" slot. Subsequently, the second side encompassed numbers "10" through "18," culminating in the "Chance" slot. Similarly, the third side spanned numbers "19" to "27," with the second "Fate" slot following. The fourth side encompassed the remaining subsections, from number "28" to "36," with the second "Chance" slot serving as the final subsection of the board game. Positioned at the centre was the title of PBBG, namely the "*SciFun* Board Game." The researcher also crafted dice and player tokens to complete the prototype.

Following the creation of the initial physical design of PBBG, the researcher transferred it to digital format using a computer. The game board was created using MS

Word, where numbers were typed sequentially for each subsection, ranging from "1" to "36." Subsequently, these numbers were printed on papers of matching colours, cut out, sorted, and finally affixed onto the game board. This process is illustrated in Figure 3.3.



Figure 3.3: First Draft of PBBG "*SciFun* Board Game"

The progression within the "Design and Develop: Add Functionality" phase persisted as the researcher selected three Science topics from the Year 4 Science syllabus, as stipulated by National-Type Chinese Primary Schools. The chosen Science topics are Chapter 5 - "Properties of Light," Chapter 7 - "Energy," and Chapter 8 - "Materials." Notably, each of these chapters was subdivided into specific subtopics to focus the educational content, such as Chapter 5 (Subtopic 5.1: Light Travels in a Straight Line, Subtopic 5.2: Reflection of Light, Subtopic 5.3: Refraction of Light), Chapter 7 (Subtopic

7.1: Sources and Forms of Energy, Subtopic 7.2: Renewable and Non-Renewable Energy) and Chapter 8 (Subtopic 8.1: Sources of Materials, Subtopic 8.2: Characteristics of Materials).

Subsequently, the researcher prepared the questions aligned with the syllabus from Year 4 Science at National-Type for Chinese Primary Schools. To achieve this, an extensive search was conducted across various educational resources, including exercise books such as *Buku Aktiviti Sains 4A, Buku Aktiviti Sains 4B, Buku Aktiviti Skills Tahun 4, Tes Topikal Arif Sains Tahun 4, Latihan Lengkap Unit Sains Tahun 4 4A,* and *Latihan Lengkap Unit Sains Tahun 4 4B*. This meticulous search yielded questions that were relevant to the selected Science topics. Each question was thoughtfully prepared and presented in multiple-choice and open-ended formats. Moreover, comprehensive answers were furnished for each question.

Every subsection within the initial draft of PBBG featured a pair of questions, irrespective of whether they were presented in a multiple-choice or open-ended format. This endeavour resulted in the inclusion of a total of 60 questions across the board game. After selecting the questions with their respective answers, the researcher used a printer to scan and digitise the materials, facilitating their organisation within MS Word. Then, the researcher printed this compilation, cutting and sorting them out accordingly.

The next step of the AGILE life cycle instructional design was "Design and Develop: Add Functionality". The researcher turned their focus towards crafting a scoreboard for the board game. This scoreboard would serve as an essential component of the gameplay experience. In pursuit of this objective, the researcher embarked on a quest to find images of "Players," each in red, black, green, and blue. Subsequently, the researcher worked on the prototype design for the scoreboard, capturing its details to suit the

requirements of the PBBG. The scoreboard design encompassed three rounds, each consisting of four gameplay instances. This cycle was then integrated with a significant marker denoting the "Total Point Reward." These efforts are shown in Figure 3.4, providing the scoreboard layout within the PBBG.

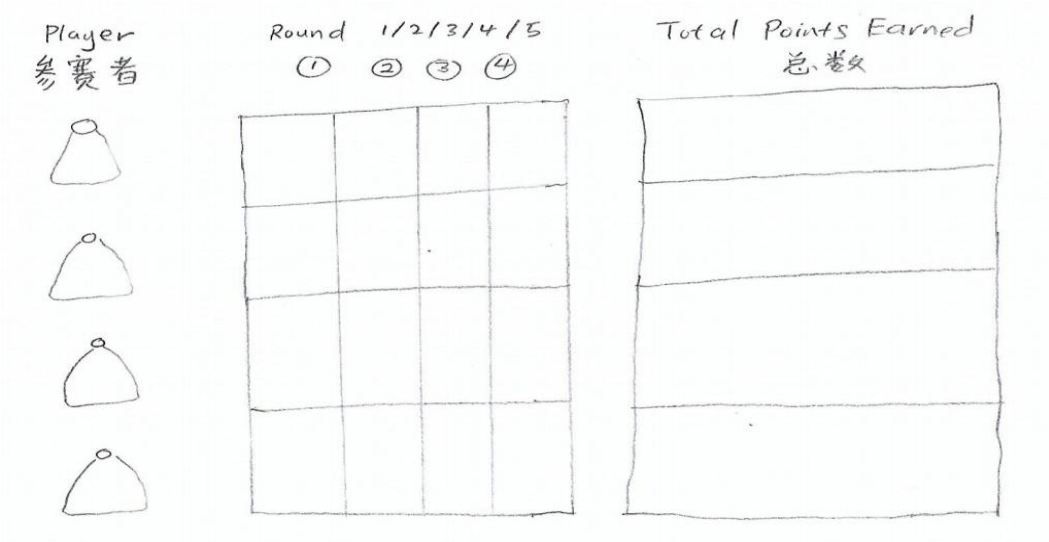


Figure 3.4: Prototype for First Draft of "Total Point Reward" Scoreboard

After finalising the scoreboard prototype, the researcher printed the materials for the scoreboard. Subsequently, the printed materials were carefully cut, laminated, and affixed to the game board. Figure 3.5 comprehensively illustrates how the scoreboard seamlessly integrates into the PBBG, enriching the gameplay experience.

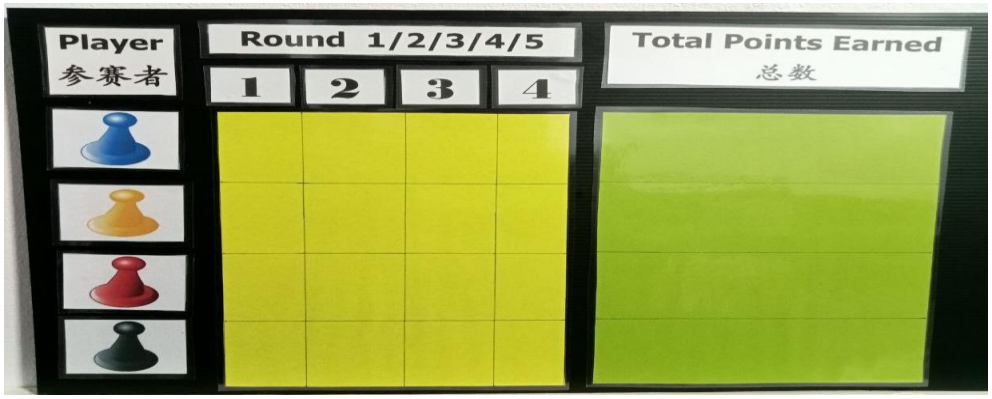
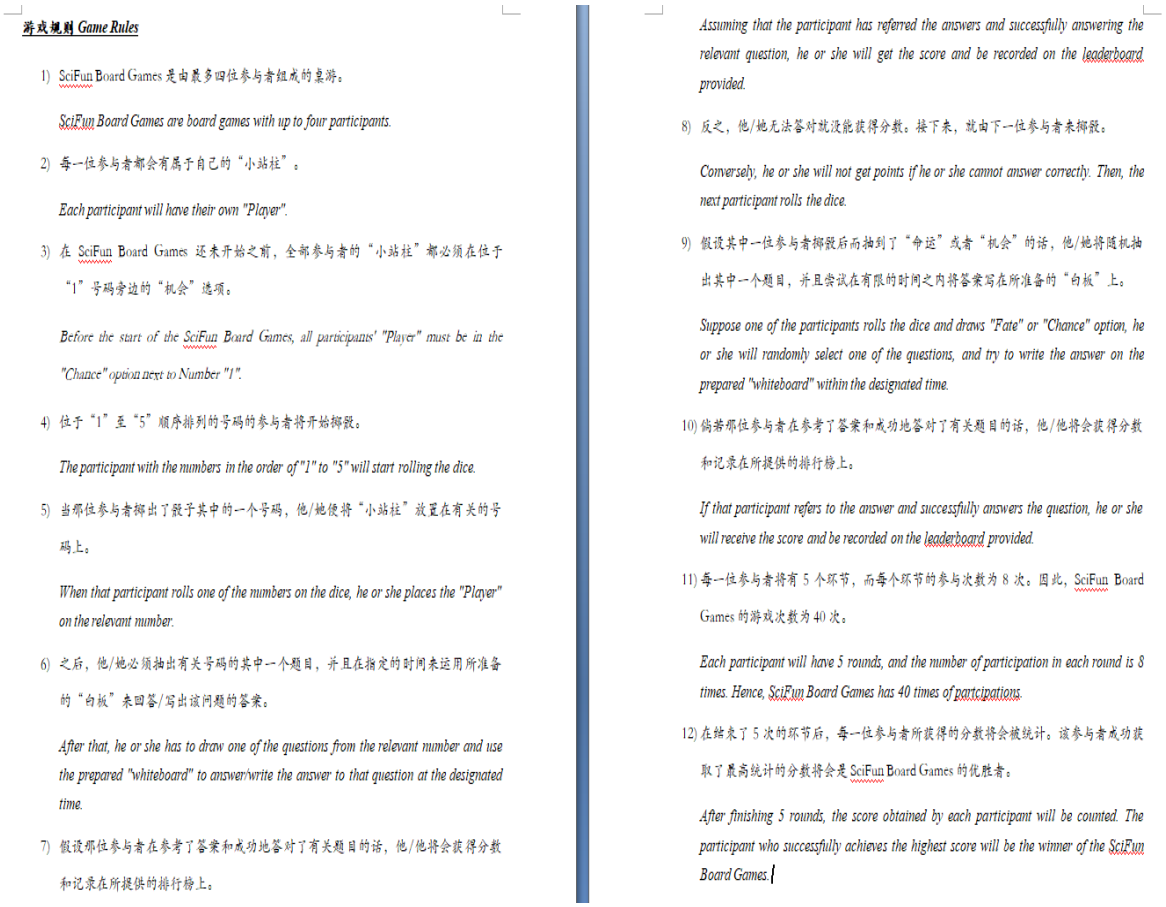


Figure 3.5: First Draft of "Total Point Reward" Scoreboard

Then, the researcher prepared the rules and regulations for playing PBBG with CL, whereas all the instructions were written using Microsoft Word, as illustrated in Figure 3.6.



游戏规则 Game Rules

1) SciFun Board Games 是由最多四位参与者组成的桌游。

SciFun Board Games are board games with up to four participants.

2) 每一位参与者都会有属于自己的“小站柱”。

Each participant will have their own "Player".

3) 在 SciFun Board Games 还未开始之前，全部参与者的“小站柱”都必须在位于“1”号码旁边的“机会”选项。

Before the start of the SciFun Board Games, all participants' "Player" must be in the "Chance" option next to Number "1".

4) 位于“1”至“5”顺序排列的号码的参与者将开始掷骰。

The participant with the numbers in the order of "1" to "5" will start rolling the dice.

5) 当那位参与者掷出了骰子其中的一个号码，他/她便将“小站柱”放置在有关的号码上。

When that participant rolls one of the numbers on the dice, he or she places the "Player" on the relevant number.

6) 之后，他/她必须抽出有关号码的其中一个题目，并且在指定的时间来运用所准备的“白板”来回答/写出该问题的答案。

After that, he or she has to draw one of the questions from the relevant number and use the prepared "whiteboard" to answer/write the answer to that question at the designated time.

7) 假设那位参与者在参考了答案和成功地答对了有关题目的话，他/他将会获得分数和记录在所提供的排行榜上。

Assuming that the participant has referred the answers and successfully answering the relevant question, he or she will get the score and be recorded on the leaderboard provided.

8) 反之，他/她无法答对就没能获得分数。接下来，就由下一位参与者来掷骰。

Conversely, he or she will not get points if he or she cannot answer correctly. Then, the next participant rolls the dice.

9) 假设其中一位参与者掷骰后而抽到了“命运”或者“机会”的话，他/她将随机抽出其中一个题目，并且尝试在有限的时间之内将答案写在所准备的“白板”上。

Suppose one of the participants rolls the dice and draws "Fate" or "Chance" option, he or she will randomly select one of the questions, and try to write the answer on the prepared "whiteboard" within the designated time.

10) 倘若那位参与者在参考了答案和成功地答对了有关题目的话，他/他将会获得分数和记录在所提供的排行榜上。

If that participant refers to the answer and successfully answers the question, he or she will receive the score and be recorded on the leaderboard provided.

11) 每一位参与者将有 5 个环节，而每个环节的参与次数为 8 次。因此，SciFun Board Games 的游戏次数为 40 次。

Each participant will have 5 rounds, and the number of participation in each round is 8 times. Hence, SciFun Board Games has 40 times of partcipations.

12) 在结束了 5 次的环节后，每一位参与者所获得的分数将会被统计。该参与者成功获取了最高统计的分数将会是 SciFun Board Games 的优胜者。

After finishing 5 rounds, the score obtained by each participant will be counted. The participant who successfully achieves the highest score will be the winner of the SciFun Board Games.

Figure 3.6: Instructions for Playing PBBG in MS Word File

The next phase of the AGILE life cycle instructional design was "Release", as the prototype of the initial draft for PBBG had been created and is ready to be released. Moving into the "Review and Revise" phase, the researcher conducted the self-assessment of PBBG before consulting two experienced Science teachers. However, the release of the initial draft for the PBBG prototype was postponed, as a few features had to be added or changed to make it more efficient. Hence, the researcher continued to proceed with the "Review and Reassess" step to add functionality to the design and development of PBBG. Informed by the insights from experienced Science educators, the researcher introduces

changes to the features of PBBG. A manual prototyping process was adopted to facilitate this modification, as visually depicted in Figure 3.7. This iterative refinement shows the agility in the AGILE approach, underscoring the commitment to continuously enhance and optimise the educational board game's design and functionality.



Figure 3.7: Prototype for Second Draft of PBBG "*SciFun* Board Game"

According to Figure 3.7, PBBG retains its four-sided structure; each side now consists of 7 subsections. Additionally, each corner features a subsection, two "Fate" slots and two "Chance" slots alternatingly. Sequential numbering is assigned to each subsection, commencing with the first "Fate" slot on the first side, followed by numbers "1" through "7.". The first "Chance" slot occupies the 8th to 14th subsection on the second side. Subsequently, the second "Fate" slot appears, spanning the 15th through 21st subsections on the third side of PBBG. The fourth side introduces the second "Chance" slot, encompassing the 22nd through 28th subsections.

While prototyping the second draft of PBBG, an adjustment was made to the positioning of the title, "*SciFun* Board Game," adopting a diagonal orientation. Furthermore, the consistent inclusion of dice and "Players" was maintained.

Upon finalising the second draft of PBBG, the researcher referenced the physical prototype, subsequently undertaking its digital creation. MS Word was used to input numerical labels for each subsection. The resulting output was printed on coloured papers—yellow, green, pink, and orange—corresponding to each side of PBBG within this research. The printed and labelled coloured papers were cut and systematically organized to align with their designated subsections. This process led to the design depicted in Figure 3.8.

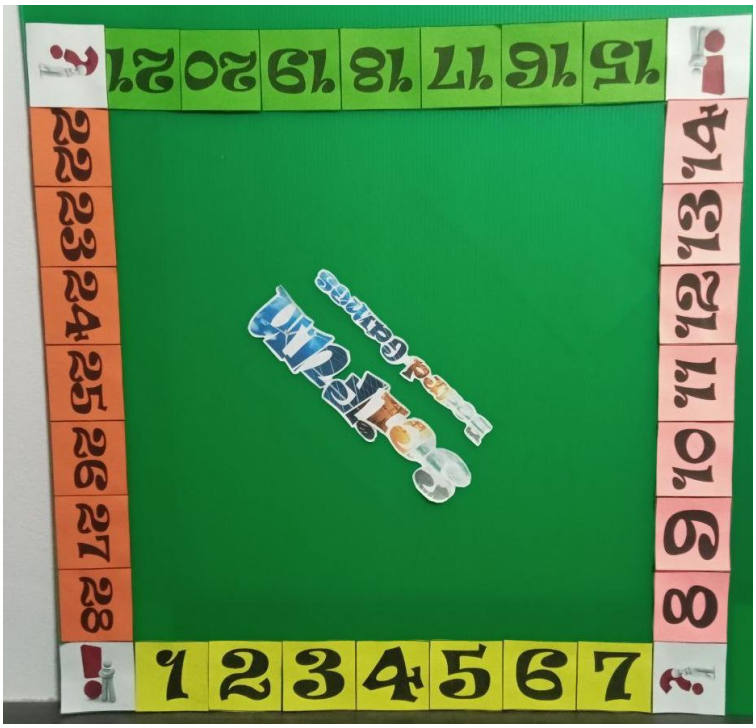


Figure 3.8: Second Draft of PBBG "*SciFun* Board Game"

The researcher decided to keep the same topics in this draft. However, additional questions related to National-Type Chinese Primary Schools' Year 4 Science syllabus were

added using additional references, such as *Pentaksiran Bilik Darjah Refleksi Pentaksiran Cemerlang SJKC Sains Tahun 4; Latihan Pengukuhan Cemerlang SJKC Sains 4A and Latihan Pengukuhan Cemerlang SJKC Sains 4B*. The questions format for PBBG remained; multiple-choice questions were focused on the first and second sides of the game board, while open-ended questions were prepared on the third and fourth sides. Answers were provided for all the questions. One hundred questions were provided in the second draft of PBBG. Subsequently, the researcher digitised and scanned all questions and answers before printing them. Finally, the printed questions were cut and arranged accordingly.

The researcher further reprioritized by adding or changing the features of the scoreboard for PBBG through prototyping. This process changed the three rounds of four times playing rules to five rounds with eight times playing, as illustrated in Figure 3.9.

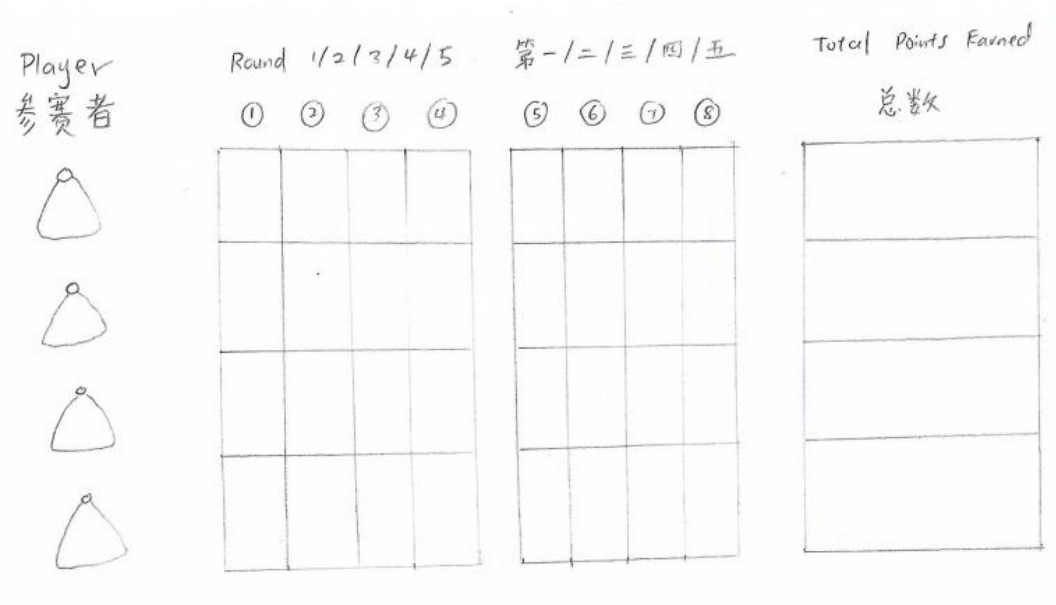


Figure 3.9: Prototype for Second Draft of "Total Point Reward" Scoreboard

After successfully prototyping the PBBG scoreboard, the researcher printed the necessary materials. These materials were subsequently cut, laminated, and affixed to the game board, as depicted in Figure 3.10.



Figure 3.10: Finalized Version of "Total Point Reward" Scoreboard

Furthermore, the rules and regulations for playing the second draft of PBBG with CL were compiled in an MS PowerPoint file, allowing for convenient reference during the activity within the Science classroom at a later time. This can be observed in Figure 3.11.

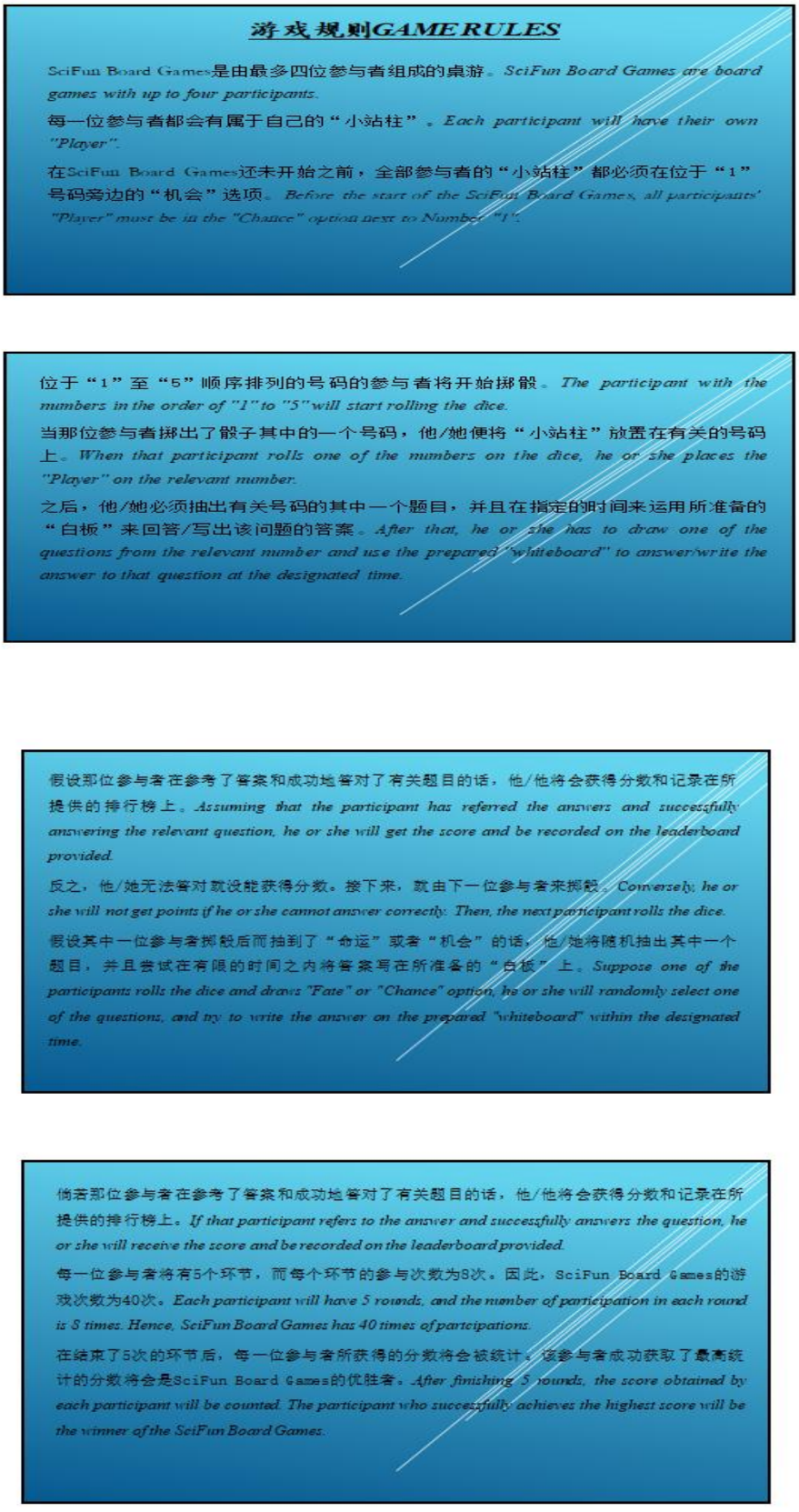


Figure 3.11: Instructions for Playing PBBG in MS PowerPoint File

The subsequent iteration was carried out as the researcher advanced to the next phase, focusing on the three core aspects of this research: academic achievement, social interaction, and learning motivation. However, the decision to employ gamification, particularly through board games, persisted in this research, and the rules and regulations for gameplay remained unchanged from the previous version of the first draft of PBBG.

Within the AGILE life cycle instructional design under the "Design and Develop: Add Functionality" segment, the researcher opted to modify the second draft of PBBG through manual prototyping. This was done to obtain the most recent iteration of the PBBG prototype. The prototype for the third draft of PBBG is depicted in Figure 3.12.

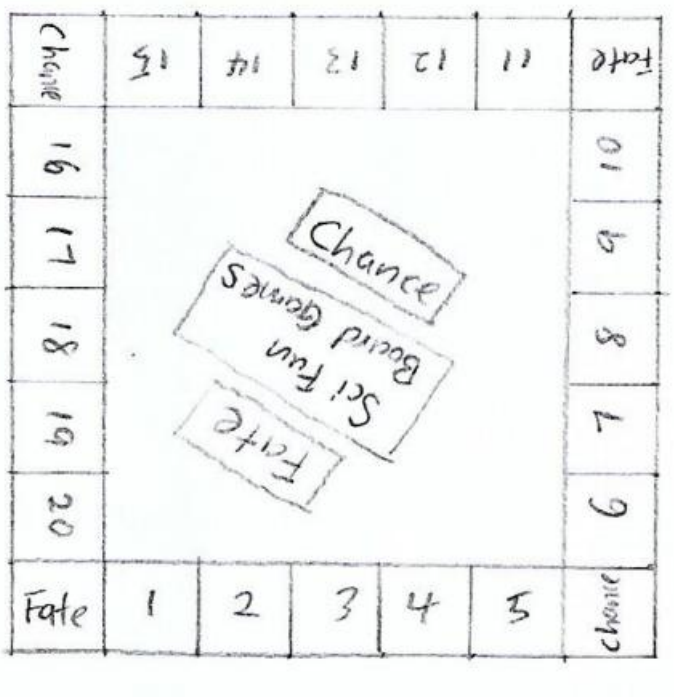


Figure 3.12: Prototype for Third Draft of PBBG "*SciFun* Board Game"

Referring to Figure 3.12, the structure of PBBG retained its four sides. However, each side now encompassed five subsections, with each corner featuring two "Fate" slots and two "Chance" slots. Numeric designations continued to denote each subsection. On the

first side, the sequence extended from the first to the fifth subsection, concluding with the first "Fate" slot. Subsequently, the second side spanned from the 6th to the 10th subsection, with the first "Chance" slot following. Furthermore, the third side of PBBG encompassed the 11th subsection through the 15th subsection, succeeded by the second "Fate" slot.

Furthermore, the fourth side of the board game encompassed the remaining subsections, spanning from the 16th to the 20th subsection, followed by the second "Chance" slot. The title "*SciFun* Board Game" persisted, while the "Fate" and "Chance" slots accommodated the questions alongside the title, arranged diagonally. Dice and "Players" components were retained.

Upon completing the third draft of PBBG, the researcher created a physical prototype using a computer. The game board was crafted using MS Word, including the 20 numbers for each side. These numbers were printed on coloured papers to enhance visibility and aesthetics. Subsequently, the printed numbers were cut, organized, and affixed to the game board.

The design and development process continued incorporating more functionality by integrating inputs and analysing feedback. This step upheld the decision to maintain the three chosen Science topics.

The researcher realized that the existing question bank for the preparation of PBBG was insufficient. Consequently, and chose to incorporate additional exercise books, such as "Siri Praktis Topikal Cemerlang SJKC Sains Tahun 4," "Praktis Dinamik Cemerlang SJKC 4A," and "Praktis Dinamik Cemerlang SJKC 4B." More relevant HOTs questions were sourced, particularly in multiple-choice and open-ended questions. These questions were carefully selected and paired with their corresponding answers. In total, 130 questions were

prepared, aiming to make PBBG more challenging and comprehensive, providing users with opportunities to engage in both gameplay and learning new concepts.

The researcher used a printer to scan these questions and answers into the computer, allowing for their arrangement and organisation within MS Word. After successfully scanning and arranging all the questions with their answers, the researcher printed, cut, and sorted them, preparing them for implementing PBBG in the Science classroom later.

In the subsequent stage of the AGILE life cycle instructional design, the focus shifted towards the "Release" step, signifying the point at which the refined version of the board game prototype was deemed ready for official release. Then, a self-assessment process occurred within the "Review and Revise" phase, wherein two experienced Science teachers were consulted to assess the board game prototype. Their valuable input was then integrated, and the final verdict was reached. PBBG had undergone the necessary iterations and enhancements and was fully prepared for its formal release. The final version of PBBG's prototype is displayed in Figure 3.13.



Figure 3.13: Finalized Version of PBBG "*SciFun* Board Game"

3.3.2 Computerized Board Games (CBG)

Based on the chosen framework, which involved adopting the AGILE life cycle instructional design, particular emphasis was placed on addressing the challenges the research participants confronted during the initial phase, commonly referred to as project initiation. In this context, the researcher intended to capitalise on this opportunity to evaluate the academic accomplishments, social interactions, and learning motivation of 10-year-old participants hailing from National-Type Chinese Primary Schools, with a special focus on Science education.

Similar to the development of PBBG with CL, identifying high-level requirements played a pivotal role. Consequently, the researcher opted to concentrate on integrating gamification into the teaching and learning of Science. Contemporary instances of game-based learning encompass various formats, from card and video games to board games.

However, amidst these alternatives, the researcher decided to leverage the medium of board games, with a specific emphasis on their digital iteration, to facilitate the teaching and learning process within the Science classroom. Creating the CBG was deemed pertinent and fitting. This selection was driven by the objective of fulfilling the specific objectives of the research, which was primarily aimed at assessing the efficacy of employing CBG with CL methodologies.

Furthermore, it is crucial to underline that CBG stands apart from PBBG in its distinct approach. CBG encompasses integrating electronic devices, effectively translating the traditional concept of board games into a digital format for this research. Consequently, the fundamental elements of a physical board game – such as chess pieces, dice, chips, cards, small plates, and data columns – have been adapted into their digital counterparts.

Also, the researcher opted to draw inspiration from a commercially established board game – the "Millionaire Monopoly Game" – to serve as a foundational guide for creating and developing CBG, tailored specifically for the pedagogical objectives of fostering Science education among the chosen group of 10-year-old participants. This strategic alignment provided the necessary framework for addressing the research questions.

Moreover, Similar to the approach taken with PBBG, the researcher undertook the task of refining and adapting the rules and regulations governing the gameplay of CBG. These adjustments were derived from the original "Millionaire Monopoly Game" core guidelines. They encompassed key facets: preparation, dice mechanics, income, player movements, "Fate" and "Chance" events, income taxation, imprisonment, release from imprisonment, and emerging as the victor. This approach was aimed to positively impact the academic progress, social dynamics, and motivational aspects of 10-year-old participants as they engaged in the collaborative exploration of scientific concepts.

Using the step outlined in the adapted AGILE life cycle instructional design, specifically the "Design and Develop: Add Functionality" phase, the researcher transforms the educational board game into its digital form, giving rise to CBG within this research framework. However, it is worth noting that the name of this digital board game remains consistent with its predecessor, adopting the name "*SciFun* Board Game."

This particular name was deliberately chosen to encapsulate the essence of integrating gamified elements into the Science classroom. The intention behind this decision was to create an engaging and enjoyable environment where the research participants could actively learn new scientific concepts while simultaneously relishing the

experience of playing CBG. Furthermore, the development of CBG took shape through manual prototyping. The final creation of the digital game board is depicted in Figure 3.14.

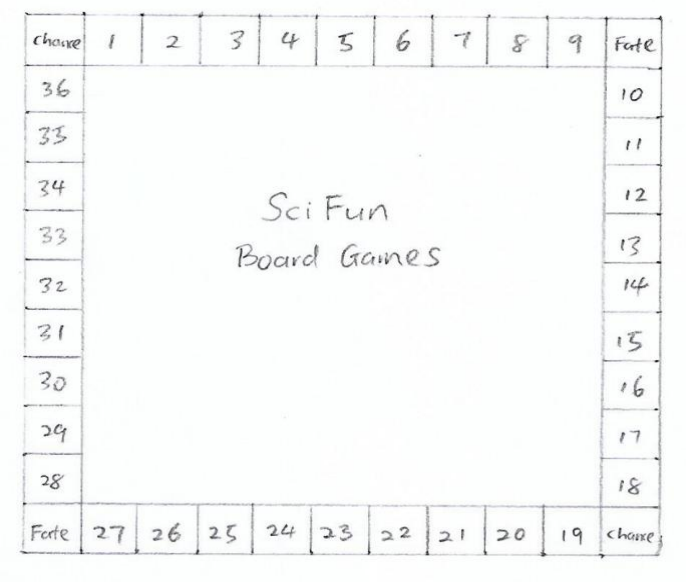


Figure 3.14: Prototype for First Draft of CBG "*SciFun* Board Game"

According to Figure 3.14, the researcher created a board game consisting of four sides, each encompassing nine subsections. This configuration resulted in a total of 36 subsections. Additionally, each corner of the board game featured four subsections, alternating between two "Fate" and two "Chance" slots.

Similar to the design approach for PBBG, these subsections were individually denoted by numbers. On the first side, the subsections were numbered from the 1st to the 9th, with the initial "Fate" slot placed immediately following them. The numbering spanned from the 10th to the 18th subsection on the second side, with the first "Chance" slot adjacent.

The third side of CBG included nine successive subsections—numbered from the 19th to the 27th—before being capped off by the second "Fate" slot. The fourth and final side integrated subsections from the 28th to the 36th, featuring the second "Chance" slot.

In keeping with continuity, the title of CBG, "*SciFu*n Board Game," was centrally positioned on the board. Accompanying this, dice and "Players" were thoughtfully provided adjacent to the title as part of the comprehensive design.

Following the conceptualisation of CBG, the researcher continued with the digital prototype using a computer. The game board's construction took place within Google Sheets, where the sequence of numbers ranging from "1" to "36" was inputted to delineate the layout of the four sides. Placing the title, *"SciFun* Board Game," in the centre of the board game was also part of this digital rendering.

Moreover, a decision was made to incorporate colour coding for the subsections, with each set of subsections sporting the same colour, a visual representation of which can be found in Figure 3.15.

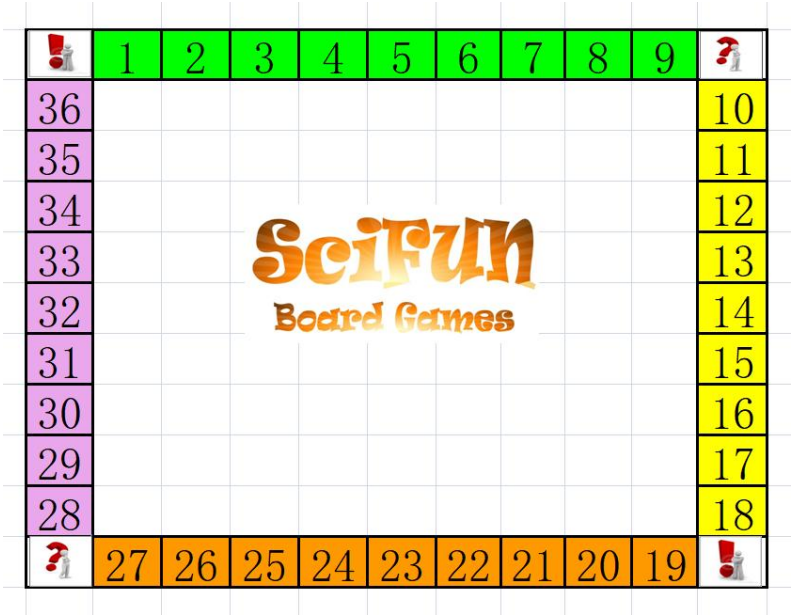


Figure 3.15: First Draft of CBG "*SciFun* Board Game"

The selected Science topics were similar to PBBG, and many exercise books were referenced, such as *Buku Aktiviti Sains 4A, Buku Aktiviti Sains 4B, Buku Aktiviti Skills*

Tahun 4, Tes Topikal Arif Sains Tahun 4, Latihan Lengkap Unit Sains Tahun 4 4A and Latihan Lengkap Unit Sains Tahun 4 4B. Moreover, two question formats were prepared, multiple-choice and open-ended, for the CBG question bank.

In addition, answers have been associated with the chosen questions. Each subsection within the initial draft of CBG accommodated two questions in the distribution of 60 questions. The process involved scanning the selected questions and their answers into the computer. Subsequently, these materials were organized in Google Sheets, with each question and corresponding answer in separate worksheets.

Moreover, following the adapted AGILE life cycle instructional design, particularly in the "Design and Develop: Add Functionality phase," a digital scoreboard was designed using Google Sheets to integrate into CBG. Various images depicting "Players" in different colours—red, black, green, and blue—were sourced. This prototype scoreboard was devised to serve the development needs of CBG. Hence, the structure featured three rounds, each encompassing four instances of gameplay. Concluding the arrangement was a column designated as "Total Point Reward," a depiction of which is visible in Figure 3.16.

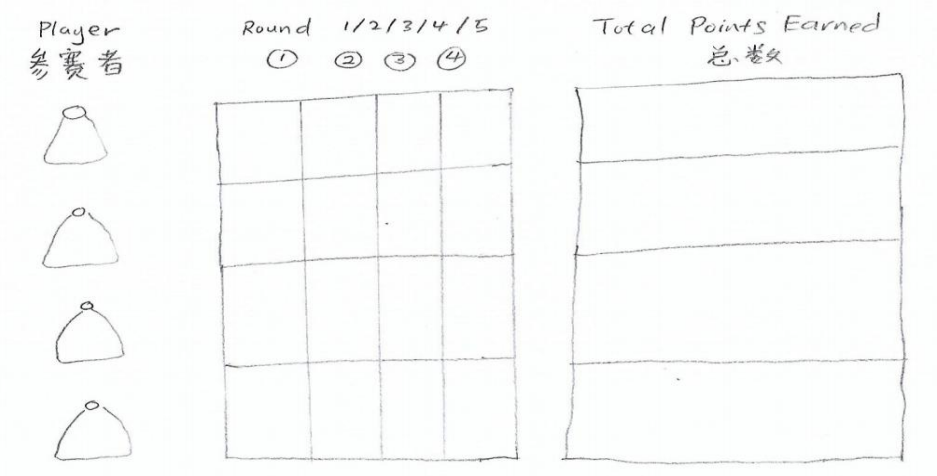


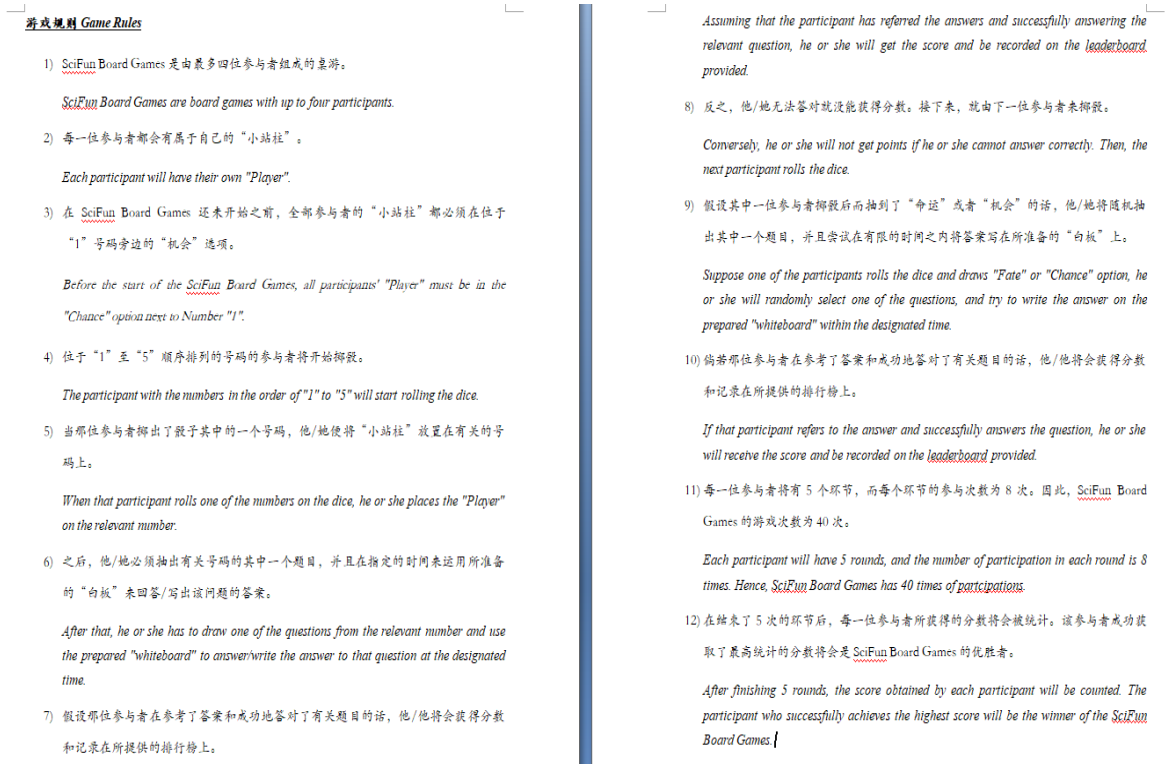
Figure 3.16: Prototype for First Draft of "Total Point Reward" Scoreboard

Once the scoreboard hadbeen prototyped, the researcher drew it in Google Sheets since it was needed for preparing CBG with collaboration through a laptop, as shown in Figure 3.17.

Player 参赛者	Round 1 第一环节				Round 2 第二环节				Round 3 第三环节				Round 4 第四环节				Total Points Earned 总数
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
																	0
																	0
																	0
																	0

Figure 3.17: First Draft of "Total Point Reward" Scoreboard

The researcher prepared the rules and regulations for playing CBG with CL, and all the instructions were written in MS Word, as illustrated in Figure 3.18.



游戏规则 Game Rules

1) SciFun Board Games 是由最多四位参与者组成的桌游。

SciFun Board Games are board games with up to four participants.

2) 每一位参与者都会有属于自己的“小站柱”。

Each participant will have their own "Player".

3) 在 SciFun Board Games 还未开始之前，全部参与者的“小站柱”都必须在位于“1”号码旁边的“机会”选项。

Before the start of the SciFun Board Games, all participants' "Player" must be in the "Chance" option next to Number "1".

4) 位于“1”至“5”顺序排列的号码的参与者将开始掷骰。

The participant with the numbers in the order of "1" to "5" will start rolling the dice.

5) 当那位参与者掷出了骰子其中的一个号码，他/她便将“小站柱”放置在有关的号码上。

When that participant rolls one of the numbers on the dice, he or she places the "Player" on the relevant number.

6) 之后，他/她必须抽出有关号码的其中一个题目，并且在指定的时间来运用所准备的“白板”来回答/写出该问题的答案。

After that, he or she has to draw one of the questions from the relevant number and use the prepared "whiteboard" to answer/write the answer to that question at the designated time.

7) 假设那位参与者在参考了答案和成功地答对了有关题目的话，他/他将会获得分数和记录在所提供的排行榜上。

Assuming that the participant has referred the answers and successfully answering the relevant question, he or she will get the score and be recorded on the leaderboard provided.

8) 反之，他/她无法答对就没能获得分数。接下来，就由下一位参与者来掷骰。

Conversely, he or she will not get points if he or she cannot answer correctly. Then, the next participant rolls the dice.

9) 假设其中一位参与者掷骰后而抽到了“命运”或者“机会”的话，他/她将随机抽出其中一个题目，并且尝试在有限的时间之内将答案写在所准备的“白板”上。

Suppose one of the participants rolls the dice and draws "Fate" or "Chance" option, he or she will randomly select one of the questions, and try to write the answer on the prepared "whiteboard" within the designated time.

10) 倘若那位参与者在参考了答案和成功地答对了有关题目的话，他/他将会获得分数和记录在所提供的排行榜上。

If that participant refers to the answer and successfully answers the question, he or she will receive the score and be recorded on the leaderboard provided.

11) 每一位参与者将有 5 个环节，而每个环节的参与次数为 8 次。因此，SciFun Board Games 的游戏次数为 40 次。

Each participant will have 5 rounds, and the number of participation in each round is 8 times. Hence, SciFun Board Games has 40 times of partcipations.

12) 在结束了 5 次的环节后，每一位参与者所获得的分数将会被统计。该参与者成功获取了最高统计的分数将会是 SciFun Board Games 的优胜者。

After finishing 5 rounds, the score obtained by each participant will be counted. The participant who successfully achieves the highest score will be the winner of the SciFun Board Games.

Figure 3.18: Instructions for Playing CBG in MS Word File

Following the subsequent phase of the AGILE life cycle instructional design, "Release",—the researcher prepared for the release of the first draft of CBG with CL. Additionally, to fulfil the "Review and Revise" element, an initial round of self-assessment was conducted before consultation with two experienced Science teachers. This approach aimed to determine the suitability of CBG for release or consider further revisions. However, a decision was made to postpone the release of the first draft of the CBG prototype due to the necessity of introducing significant features or modifications to ensure its comprehensive transition into a digital board game format. Consequently, within the "Review and Reassess" phase, additional functionality was incorporated into the design and development of CBG in this research endeavour. Through interactions with the aforementioned experienced Science teachers, refinements were identified, and a more refined iteration of the CBG prototype was generated, as illustrated in Figure 3.19.

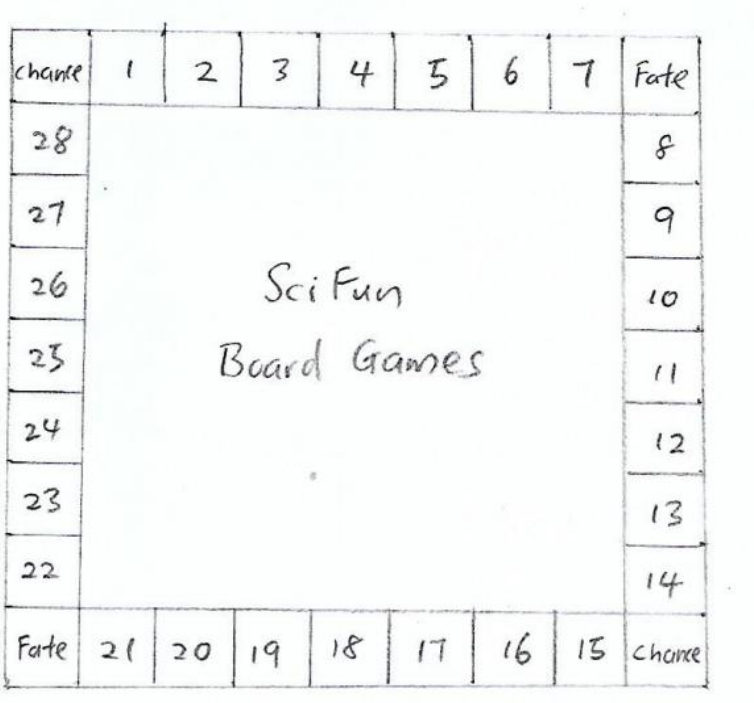


Figure 3.19: Prototype for Second Draft of CBG "*SciFun* Board Game"

Based on Figure 3.19, the game board of CBG featured four distinct sides, each encompassing seven subsections. Furthermore, each corner of the board accommodated a single subsection, alternately designated as two "Fate" slots and two "Chance" slots. A unique number denoted every subsection. The first side initiated with the introductory "Fate" slot, followed by consecutive assignments from the first to the seventh subsection. On the opposing corner of the game board, the first "Chance" slot was positioned, followed by the integration of an additional seven subsections, encompassing the 8th subsection to the 14th subsection, on the second side. The sequence introduced the second "Fate" slot, accommodating the 15th subsection through the 21st subsection on the third side of the game board.

Furthermore, the second "Chance" slot was strategically placed, and the fourth side of the CBG game board encompassed the remaining subsections, encompassing the 22nd subsection through the 28th subsection. Importantly, the positioning of the board game's title, "*SciFun* Board Game," was oriented diagonally during the creating of the second draft prototype for CBG. Similar to the PBBG, the presence of dice and "Players" was maintained.

Following the concept formulation for the second draft of CBG, the researcher developed the digital prototype using a computer. The game board was generated utilizing Google Sheets to achieve this, with each subsection assigned a distinct number. This process was conducted successively across four sides, ranging from "1" to "28". The title "*SciFun* Board Game" was inscribed in a strategically diagonal position on the board. Moreover, following the differentiation for each side, four unique colours were assigned, contributing to the visual distinction of the game board, as depicted in Figure 3.20.

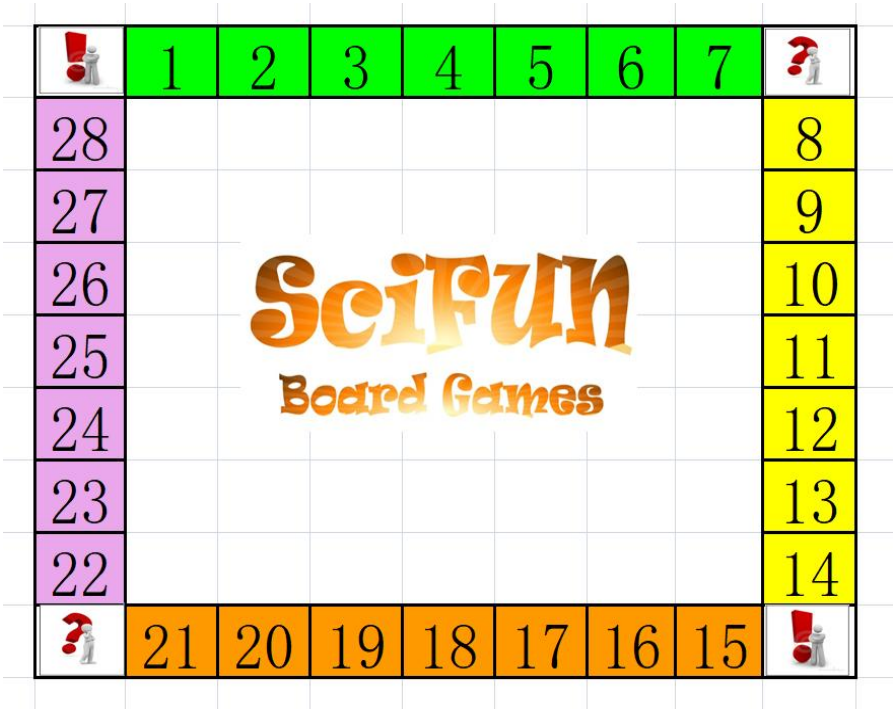


Figure 3.20: Second Draft of CBG "*SciFun* Board Game"

The researcher maintained the decision for the selected Science topics. However, it was decided to add more exercise books that were similar to PBBG, such as *Pentaksiran Bilik Darjah Refleksi Pentaksiran Cemerlang SJKC Sains Tahun 4; Latihan Pengukuhan Cemerlang SJKC Sains 4A and Latihan Pengukuhan Cemerlang SJKC Sains 4B*. Furthermore, the question formats for CBG were consistently maintained: multiple-choice questions for the first two sides and open-ended questions for the last two sides. Answers were provided to accompany these questions. Consequently, a substantial number of questions and corresponding answers were compiled for the second draft of CBG. These materials were scanned into the computer and subsequently organized in Google Sheets as required.

Moreover, in alignment with the subsequent stage of the adapted AGILE life cycle instructional design, the researcher re-evaluated, enhanced, and possibly altered the

attributes of the preceding scoreboard model intended for CBG. Consequently, the initial structure of three rounds containing four play instances was adapted and evolved into a new arrangement featuring five rounds, each encompassing eight play instances, as illustrated in Figure 3.21.

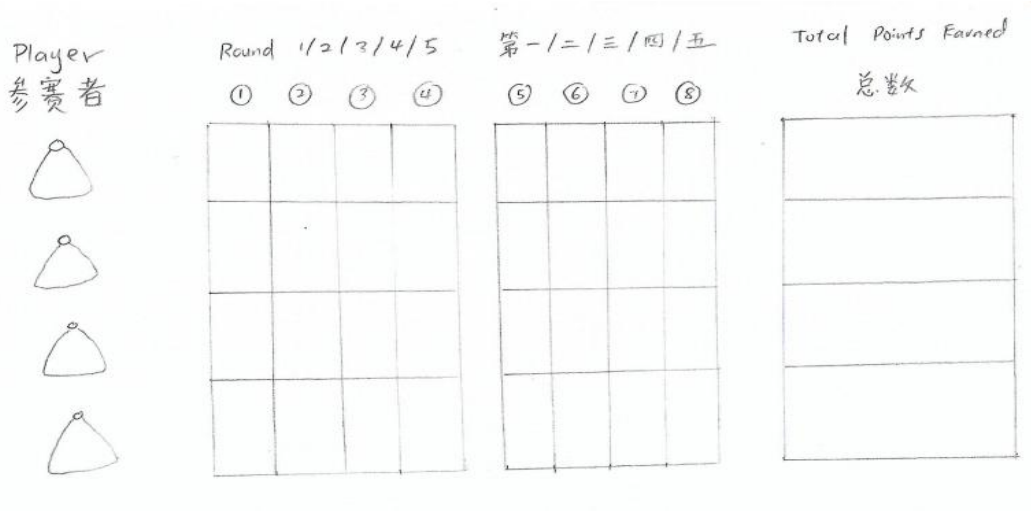


Figure 3.21: Prototype for Second Draft of "Total Point Reward" Scoreboard

Once the digital prototype of the second draft of CBG's scoreboard had been crafted, it was constructed using Google Sheets. Each component was integrated into the design, resulting in a fully realized version, as visually depicted in Figure 3.22.

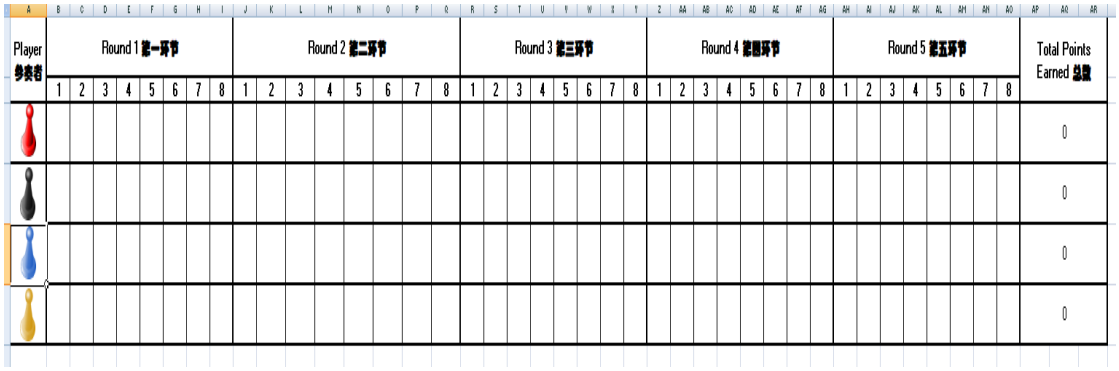
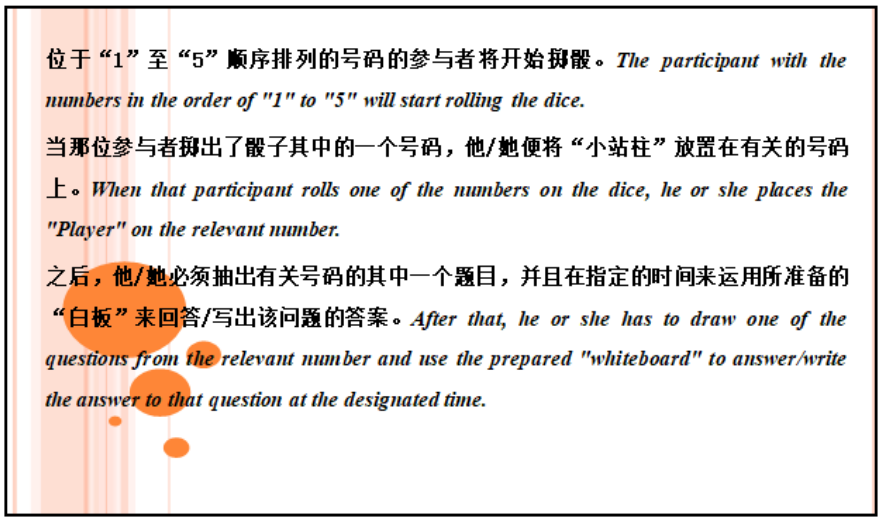


Figure 3.22: Finalized Version of "Total Point Reward" Scoreboard

In addition, the researcher took the initiative to revise and refine the rules and regulations governing the gameplay of the second draft of CBG. These modifications were documented in an MS PowerPoint presentation, offering a user-friendly reference for participants engaging with CBG within the Science classroom setting. The details of these adaptations can be observed in Figure 3.23.





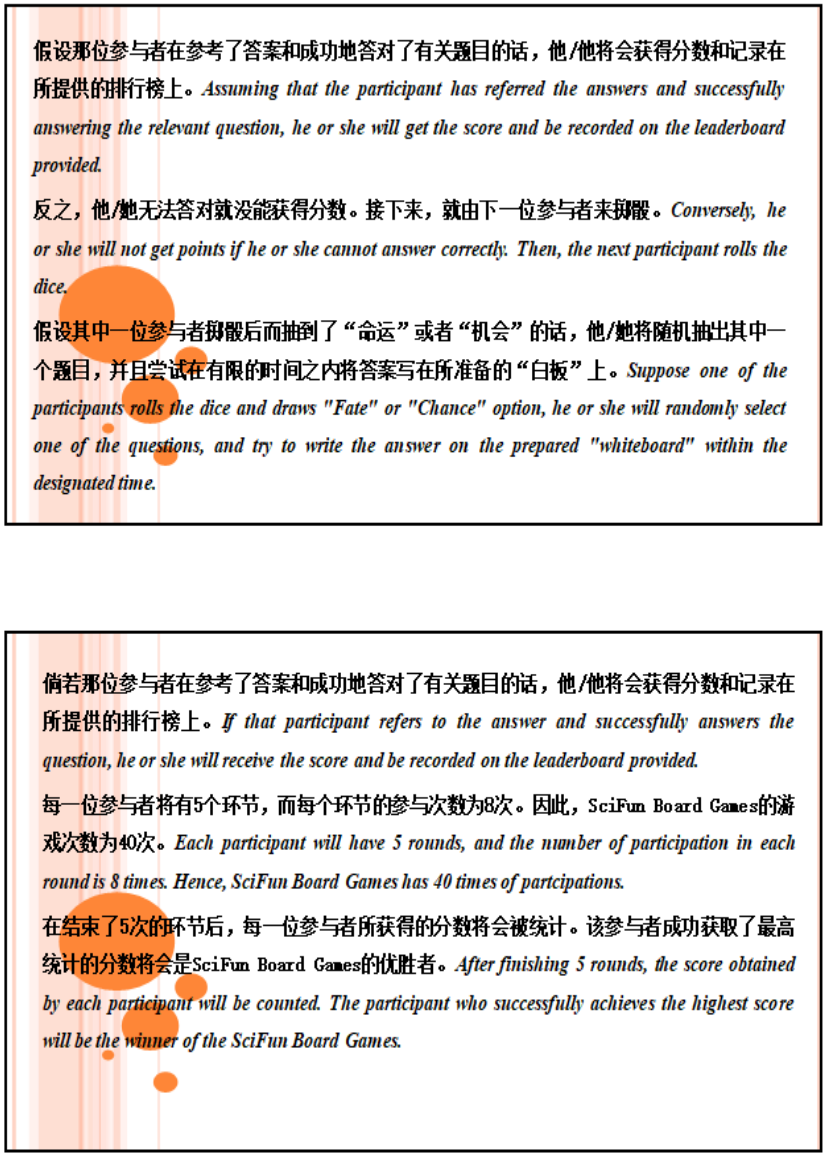


Figure 3.23: Instructions for Playing CBG in MS PowerPoint File

The next iteration was conducted as the researcher progressed to the subsequent phase, focusing on three aspects: academic achievement, social interaction, and learning motivation within the Science classroom. Furthermore, a decision had been reached regarding gamification, primarily centred on CBG. Furthermore, the rules and regulations for playing the game were retained from the previous version of the initial draft of the board game.

Under the segment "Design and Develop: Add Functionality," the researcher opted to modify certain features based on the second draft of CBG. This involved a manual prototyping process to refine the design iteratively and ultimately reflected in the final version of the CBG prototype in this research. The prototype for the third iteration of CBG is illustrated in Figure 3.24.

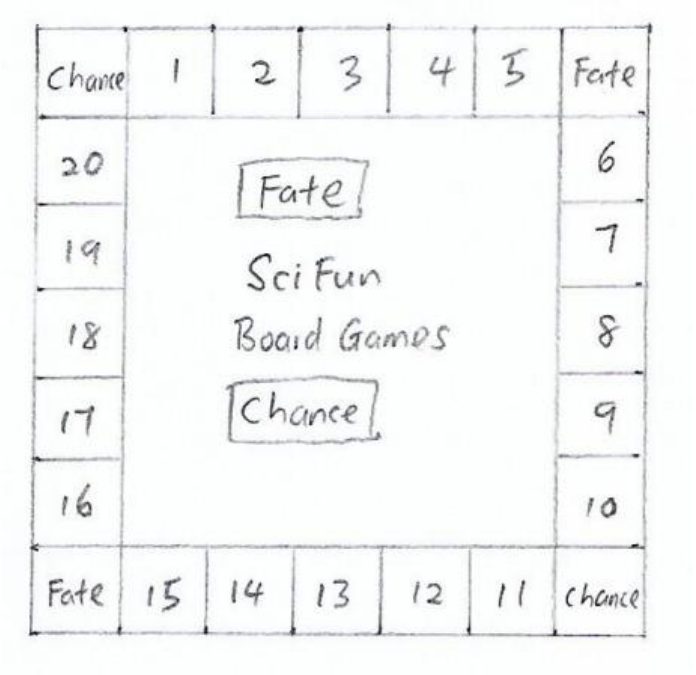


Figure 3.24: Prototype for Third Draft of CBG "*SciFun* Board Game"

According to Figure 3.24, the four sides of the CBG board were retained. However, each side is now divided into five subsections, with each corner of the board featuring two "Fate" and two "Chance" slots in an alternating pattern. Numerical identifiers continue representing each subsection, progressing from the 1st to the 5th. Subsequently, the first "Fate" slot is followed by subsections 6 to 10 on the second side, alongside the placement of the first "Chance" slot. The third side of CBG continues with another set of five subsections (11th to 15th), with the addition of the second "Fate" slot. Finally, the fourth side of CBG encompasses the remaining subsections (16th to 20th) alongside the second

"Chance" slot. The title "*SciFun* Board Game" is retained for CBG, albeit with the addition of a "Fate" slot and a "Chance" slot placed adjacent to the title, facilitating the incorporation of questions in a diagonal arrangement. Dice and "Players" elements remain present.

Following the confirmation of the concept for the third draft of CBG, a digital prototype was crafted using a computer. In this process, the game board was developed using Google Sheets. Each subsection is denoted by a numerical value ranging from "1" to "20" across all four sides. The title "*SciFun* Board Game" is positioned diagonally within CBG, with each side designated a distinct colour for differentiation.

Continuing with the next phase of the adapted AGILE life cycle instructional design, "Design and Develop: Add Functionality," the researcher focused on refining the question pool for CBG. The three selected Science topics were maintained. However, to enhance the question variety, additional exercise books were integrated into the preparation process, including "Siri Praktis Topikal Cemerlang SJKC Sains Tahun 4," "Praktis Dinamik Cemerlang SJKC 4A," and "Praktis Dinamik Cemerlang SJKC 4B." The primary goal was to incorporate a diverse range of HOTs questions, encompassing multiple-choice and open-ended formats, providing participants with an engaging and educational experience. As a result, 130 questions were compiled to ensure that CBG offers a challenging and enriching learning opportunity. These questions were scanned into a computer and organized within Google Sheets.

Additionally, the next stage of the adapted AGILE life cycle instructional design, "Release," marked the finalisation of the CBG prototype with CL. Self-assessment was conducted during the "Review and Revise" phase, involving two experienced Science teachers who tested the CBG prototype. Following their feedback and assessment, CBG

was deemed ready for formal release. The finalized version of CBG is visually represented in Figure 3.25.

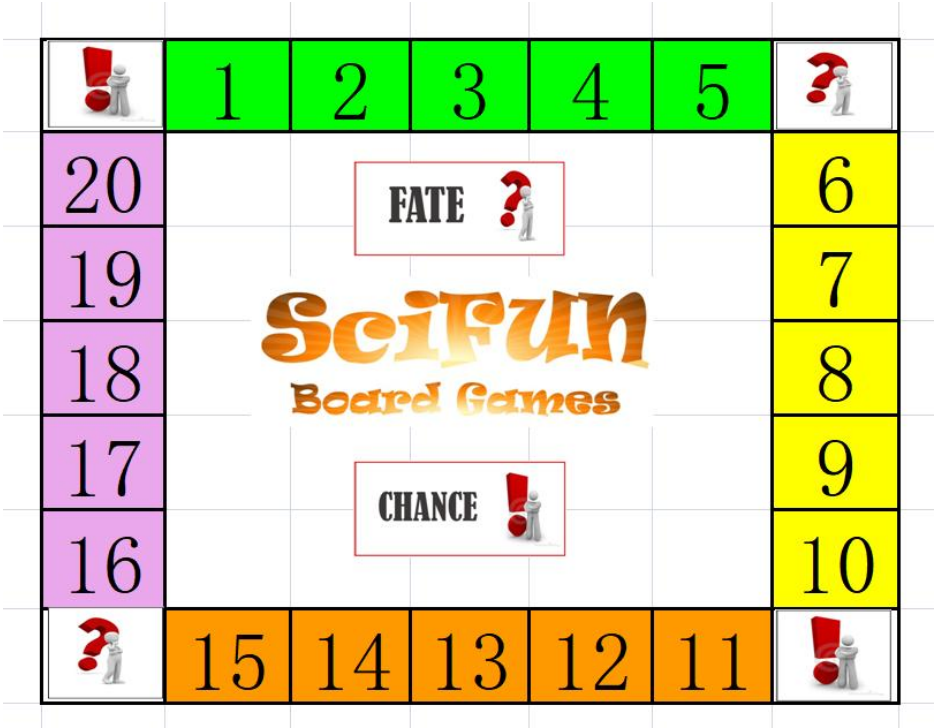


Figure 3.25: Finalized Version of CBG "*SciFun* Board Game"

3.4 Playtesting the Board Games

3.4.1 Paper-Based Board Games (PBBG)

Playtesting PBBG was conducted using a systematic and iterative approach to evaluate and enhance the game's various components and aspects. This process involved comprehensive mechanics, rules, player experience, and component functionality assessment. By gathering feedback and observing participants' interactions with the game, the researcher aimed to understand strengths, weaknesses, and areas needing improvement. This iterative cycle of testing and refining contributed to creating a more captivating, balanced, and enjoyable gameplay experience.

Initial Prototype:

The playtesting process for PBBG begins with an initial prototype that includes all essential components of the game, such as the game board, cards, dice, players, and rulebook. At this stage, the prototype does not need to be visually polished; instead, the emphasis is on testing and refining the mechanics and gameplay mechanics. This helps identify any issues or areas that require improvement regarding how the game functions and players interact.

Define Objectives:

During the playtesting phase for PBBG, clear goals and objectives were established. The primary focus was on evaluating and assessing various aspects of the board game, including the clarity of rules, the level of player interaction, the impact on learning motivation, and the overall enjoyment of the game experience.

Select Playtesters:

In this research, four Science teachers from a National-Type Chinese Primary School actively participated as playtesters for the PBBG. Their involvement was instrumental in providing valuable insights and feedback from various angles, including learning motivation and social interaction that emerged during the gameplay. This diverse feedback helped identify strengths and areas for improvement in the game's mechanics and overall experience.

Pre-Playtest Briefing:

Before the playtest session, the playtesters were provided with an introduction to the rules, objectives, and specific guidelines of the PBBG. This step was taken to ensure

that all playtesters had a shared comprehension of the board game, enhancing the consistency of their feedback and evaluation process.

Conduct Playthroughs:

The researcher facilitated several playthroughs of the PBBG with the four playtesters. Throughout these play sessions, the researcher observed and analyzed how the playtesters engaged with the game mechanics, formulated decisions and devised strategies. Additionally, the researcher remained attentive to instances where playtesters exhibited confusion, hesitation, or enthusiasm during different gameplay phases. This comprehensive observation allowed a thorough understanding of how the board game functioned practically.

Collect Feedback:

Following each playthrough, the researcher organized a dedicated feedback session, providing the playtesters a platform to express their insights, opinions, and recommendations. During these discussions, the playtesters were encouraged to offer positive feedback and constructive criticism. The emphasis was placed on fostering an open and honest exchange of viewpoints, enabling the collection of valuable input that would aid in refining and enhancing the PBBG.

Document Observations:

Throughout the playtest sessions, the researcher recorded comprehensive notes, including gameplay occurrences, identified issues, participants' reactions, and notable insights shared by the playtesters. This documentation was vital for analysing recurring patterns, addressing improvement areas, and making well-informed design choices.

Analyze Data:

The researcher reviewed and analyzed the feedback and observations gathered from playtesters. Furthermore, recurring patterns, common challenges, and areas of improvement were identified. This data was applied to prioritize changes and enhancements of the PBBG.

Iterate and Adjust:

Based on the feedback and observations from those playtesters, it was necessary to make adjustments to the PBBG. This involved tweaking rules, rebalancing mechanics, clarifying instructions, or refining components. Therefore, the prototype's new version incorporating these changes has been created.

Repeat Playtesting:

The researcher decided to conduct additional playtest sessions with the updated prototype. This iterative cycle of playtesting, feedback, and iteration was repeated multiple times to ensure that the PBBG evolved and improved in each iteration.

Diversify Playtesters:

As the game progresses, it is important to consider involving new playtesters to gain fresh perspectives. Their feedback could help the researcher identify issues that may have been missed in previous rounds of testing.

Continuous Improvement:

The researcher continuously analyzed the feedback, made necessary adjustments, and iterated on the game design until the desired level of engagement and enjoyment was achieved.

Final Polishing

As the PBBG design matured and neared completion, the researcher focused on refining the visual design, layout, and components to enhance the overall user experience.

3.4.2 Computerized Board Games (CBG)

Like PBBG, playtesting CBG also involved a structured and iterative approach to evaluating and refining the digital adaptation of traditional board games. This process ensured that the game mechanics, user interface, player experience, and technical aspects were thoroughly tested and optimised to gain a seamless and enjoyable gameplay experience for CBG.

Initial Prototype:

It began with creating a digital game prototype, including the game board, components, and user interface elements. This prototype did not require to be visually polished at this stage. However, it should accurately represent the core mechanics and functionality of CBG.

Define Objectives:

The researcher outlined the objectives of the playtesting phase as specific aspects were evaluated, such as user interface design, game mechanics, player interaction and overall user enjoyment.

Select Playtesters:

Four Science teachers were selected to become playtesters for CBG. This may include the playtesters with different skill levels, preferences, and familiarity with the PBBG before.

Pre-Playtest Briefing:

The researcher later provided the playtesters with an overview of CBG's mechanics, rules, objectives and other specific guidelines for testing purposes. It was essential for them to understand how to navigate the digital interface of CBG.

Conduct Playthroughs:

Those playtesters engaged in multiple playthroughs of the CBG. The researcher observed how they interact with the user interface to make decisions and experience the gameplay. Any issues, confusion, or moments of engagement were noted.

Collect Feedback:

After each playthrough, the researcher facilitated a feedback session where the playtesters shared their thoughts, impressions, and suggestions. They were encouraged to provide insights on positive aspects and areas needing improvement.

Document Observations:

Like PBBG, the researcher took detailed notes during playtesting sessions, capturing specific interactions, user interface challenges, and player reactions. Hence, these observations were essential for addressing issues and making informed design decisions.

Analyze Data:

The researcher reviewed and analyzed the feedback and observations from playtesters. Thus, recurring patterns, common challenges, and areas of improvement were identified, as the data were used to prioritize changes and enhancements for preparing CBG.

Iterate and Adjust:

Based on the feedback and analysis, the researcher made necessary adjustments to the CBG. This could involve refining the user interface, adjusting multiplayer behaviour, improving tutorial elements, or enhancing overall gameplay.

Replaytesting:

The researcher conducted additional playtest sessions with the updated version of the CBG. This iterative cycle of playtesting, feedback, and iteration may be repeated multiple times to ensure a smooth and engaging gameplay experience forth participants later.

User Interface Optimization:

The researcher paid special attention to the user interface design, ensuring it was intuitive, visually appealing, and functional. Then, its layout, colours, buttons, and navigation elements were adjusted based on feedback from the playtesters.

Multiplayer Testing:

If CBG features required multiplayer modes, the researcher conducted specific playtests to evaluate the behaviour of multiplayer and the performance of their online interactions.

Compatibility Testing:

The researcher tested the CBG on various devices, operating systems, and screen sizes to ensure compatibility and optimal performance across different platforms.

Continuous Improvement:

The researcher monitored players' feedback and engagement. CBG was regularly updated based on their feedback and emerging issues to maintain a high-quality experience.

Final Polishing:

Before release, the researcher focused on fine-tuning the game, optimizing performance, and ensuring a cohesive and enjoyable gameplay experience among the players.

3.5 Possible Changes and Improvements

3.5.1 Paper-Based Board Games (PBBG)

During the playtesting phase of PBBG, the researcher identified potential changes and improvements that can enhance the overall gameplay experience among the participants. These adjustments were crucial for refining mechanics, addressing issues, and ensuring the game was engaging and balanced.

Rule Clarification and Simplification:

Undeniably, playtesting could be used to reveal instances where rules were unclear or complex. The researcher should revise and simplify the rule explanations, making them

more concise and easy to understand. Clear rules can reduce player confusion and create a smooth gameplay flow.

Balancing Mechanics:

Playtesting helps to identify imbalances in gameplay mechanics for the implementation of PBBG. The researcher could adjust the strength of certain actions, abilities, or resources to ensure that no single strategy dominates the gameplay, so it creates a more competitive and enjoyable experience for all the participants.

Player Interaction:

In this research, the feedback from the playtesters may highlight the opportunities to enhance the social interaction between players while playing PBBG. The researcher can introduce or modify game mechanics that encourage negotiation, alliances, or competition between players, as it can strengthen the players' social interaction and increase their engagement and strategic depth.

Pacing and Flow:

Through playtesting, the PBBG uncovers the pacing issues, such as slow or rushed gameplay phases. The researcher could fine-tune the progression of the PBBG, adjusting turn order, round structure, or resource availability to maintain an engaging and balanced tempo among the players.

Component Functionality:

In this research, playtesting the PBBG may reveal issues with the functionality or usability of components such as cards, tokens, or game pieces. Hence, the researcher can make appropriate adjustments to ensure those components are easily handled and effectively contribute to the PBBG gameplay.

Feedback and Scoring Mechanisms:

Playtesters' input can shed light on the effectiveness of feedback and scoring mechanisms in the PBBG. The researcher can refine scoring systems, point calculations, or victory conditions to accurately reflect player performance and strategy during the implementation of PBBG.

Theme Integration:

Playtesting can showcase opportunities to strengthen the integration of the game's theme with its mechanics in this research. The researcher may adjust its components and actions to enhance thematic immersion and create a more immersive player experience while implementing the PBBG.

Player Feedback Integration:

Playtesters' suggestions and insights can drive iterative changes. Hence, the researcher should carefully consider player feedback, prioritize adjustments that align with the PBBG's vision, and implement changes that enhance the overall experience among the players.

Accessibility and Inclusivity:

In this research, playtesting the PBBG may reveal areas where the game may not be accessible or inclusive to all players. Therefore, the researcher can make adjustments to accommodate various player abilities, ensuring that the game is enjoyable for a diverse scope of players.

3.5.2 Computerized Board Games (CBG)

In this research, playtesting the CBG was a vital step in identifying potential changes and improvements that can enhance the overall gaming experience. These adjustments range from fine-tuning mechanics and user interface elements to addressing technical issues and optimising gameplay.

User Interface Refinement:

Playtesting can reveal aspects of the User Interface (UI) that may be unclear, cumbersome, or counterintuitive. Therefore, the researcher can refine the layout, icons, buttons, and menus to ensure that players can easily navigate and interact with the gameplay of CBG.

Tutorial and Onboarding:

Based on playtesters' feedback, the researcher can improve the tutorial and onboarding process to provide clearer instructions, interactive guidance, and tooltips that help new players understand the CBG's mechanics and features.

Accessibility Options:

In this research, playtesting insights may lead to adding accessibility options, such as adjustable text size, colourblind modes, and customisable controls, to ensure that the CBG is playable and enjoyable for a diverse scope of participants in the future.

Balancing and Mechanics:

Playtesting CBG can reveal imbalances or unintended interactions in gameplay mechanics. The researcher can adjust abilities, resources, or probabilities to ensure that no

strategy becomes overwhelmingly dominant to each other during the implementation of CBG among the participants.

Player Feedback Integration:

Insights from playtesters' feedback can drive iterative changes for the CBG in this research. The researcher should carefully consider players' suggestions, prioritize improvements, and implement changes that enhance the CBG gameplay and overall satisfaction among the players.

Multiplayer Enhancements:

Based on playtesters' experiences, the researcher can enhance multiplayer features, such as matchmaking algorithms and online connectivity, to create a seamless and engaging multiplayer experience.

Additional Content:

In this research, playtesting may indicate opportunities to introduce new content for the CBG, such as additional characters, scenarios, or items, to enrich the game and provide players with more options and variety in the future.

Integration of New Technologies:

In this research, playtesting insights may prompt the integration of emerging technologies such as virtual reality (VR), augmented reality (AR), or voice recognition to enhance the immersive and interactive aspects of the CBG in the future.

3.6 Further Potential for Future Development

3.6.1 Paper-Based Board Games (PBBG)

The playtesting phase of PBBG can help refine the current version of the board game and provides valuable insights and ideas for potential future development. These insights can guide designers and developers in expanding and evolving the game to offer new experiences and engage players over time.

Expansion Packs:

Playtesting can reveal opportunities to introduce expansion packs with new components, mechanics, characters, or scenarios to the PBBG. These expansions can enhance replayability and offer fresh challenges for players familiar with PBBG.

Modular Gameplay:

Designers can use playtest feedback to develop modular components or alternate rule sets that allow players to customise their gameplay experience. This can include different objectives or rule variations that players can mix and match to create unique PBBG sessions.

Collaborative Modes:

Playtesting PBBG may indicate a demand for collaborative gameplay experiences. Future development can focus on creating dedicated modes that cater to single players or collaborative groups, providing alternative ways to enjoy the CBG.

Collaborations and Licensing:

Based on playtest feedback, the designers may consider collaborations with other franchises or brands to create themed versions of the CBG that resonate with different scopes of players.

Alternate Art and Themes:

Future development can explore alternate art styles and themes for the CBG, allowing the players to experience the same mechanics in different immersive educational settings.

Accessibility and Inclusivity:

Playtesting insights may lead to initiatives for making the PBBG more accessible and inclusive, including rulebook translations or other adaptations to accommodate various player needs in the future.

Community Engagement:

Playtesting can guide designers in fostering a strong community around the game through forums, social media, and organized play events. This community engagement can contribute to ongoing development and player feedback while playing PBBG.

3.6.2 Computerized Board Games (CBG)

In this research, playtesting CBG helps refine the current digital version and opens up possibilities for future development. The insights gained from playtesting can guide designers and developers in expanding and evolving the game to offer new features, gameplay modes, and experiences that keep players engaged and excited.

User-Generated Content:

Feedback from playtesting the CBG can lead to implementing user-generated content features, allowing players to create and share their custom scenarios, characters, and rules.

Cross-Platform Play:

Playtesting the CBG can guide the integration of cross-platform play, enabling players on different devices to connect and compete against each other. This feature can expand the player base and foster a sense of community.

Competitive Modes:

Playtesting the CBG may indicate interest in competitive modes, such as ranked matchmaking, leaderboards, and competitive events that challenge players to showcase their skills on a larger scale in the future.

Cooperative Challenges:

Players' feedback can inspire it, as the designers can create cooperative challenges or modes that encourage teamwork and strategic collaboration among players.

Virtual Reality (VR) Integration:

Playtest the CBG insights can inspire the integration of VR technology, allowing players to immerse themselves in the game world and interact with components more effectively.

Augmented Reality (AR) Elements:

Future development can explore incorporating AR features that enhance the gameplay experience by overlaying digital elements onto the physical environment.

Digital Integration:

Based on playtest feedback towards CBG, the designers can explore opportunities for digital integration, such as companion apps that enhance the gameplay experience with interactive elements, tutorials, or additional content.

Voice Integration:

Future development can include voice integration, allowing the players to interact with the CBG using voice commands or engage in voice chat during multiplayer matches.

Accessibility Features:

Feedback from playtesting the CBG can lead to implementing accessibility features, such as customisable controls, subtitles, and options for players with different abilities.

Social Integration:

Playtesting insights may prompt integrating social features, such as sharing achievements, progress, and in-game creations on social media platforms.

3.7 Summary

This chapter delved into AGILE system development and its application in developing PBBG and CBG. It encompasses the fundamental principles of AGILE, benefits, and adaptable framework. The chapter also further examined the intricate processes of designing, developing, and playtesting both versions of board games. It concludes by highlighting the potential for changes, improvements, and future expansions within the realm of board game design. The next chapter focuses on the methodologies, as

they were applied to determine the implementation of PBBG and CBG, with CL towards the effectiveness, learning motivations and social interaction among 10-year-old participants from National-Type Chinese Primary Schools.

CHAPTER 4

METHODOLOGY

4.1 Introduction

Various teaching methods have been tested and employed by educators in Malaysia to cater to the diverse needs of students in the field of Science (Hui et al., 2022; Ismail et al., 2022). These methods included teacher exposition (Baptista & Molina-Andrade, 2021; Mahmud et al., 2018), discussion method (Izzaturrahmah et al., 2022), cooperative learning (Zurweni et al., 2022), lecture method (Shah et al., 2022), experimental method (Naim et al., 2022), inquiry approach method (Gao et al., 2022; Karpudewan et al., 2022); process-based teaching method (Önder et al., 2022), project method (Juuti et al., 2021; Nurilloyevn, 2021), demonstration method (Robledo et al., 2021; Sotivoldievich & Rakhimdjanovich, 2021) and field trip (Nuni, 2021). In addition, an effective method employed in Science education is allowing the students to make independent discoveries (Chusni et al., 2022), where students can collaborate in groups and utilize educational technology to acquire new information and knowledge (Nurmukhammad et al., 2022).

This research adopted an experimental design to investigate using PBBG and CBG through electronics for CL in a classroom setting. This investigated the effectiveness of PBBG and CBG in facilitating CSCL activities.

This chapter was organized into several sections. Section one elucidated the research design, while section two briefly introduced the population and sampling methods. Section three outlined the ethical consideration taken into account during the research. Section four focused on measures to ensure data validity and reliability.

Subsequently, section five emphasized using research instruments, followed by research procedures. Finally, this chapter also delved into the data collection methods and analyses.

4.2 Research Design

This research employed a true experimental design, employing a commonly used pretest-posttest design between-groups to conduct this research. In addition, the chosen design included a pre-test before the experiment, which enhanced the data accuracy by enabling comparison conditions before and after the experiment.

Three teaching methods were implemented in this research: CT, PBBG and CBG. The CT method involved using teaching aids such as video, audio or relevant pictures incorporated into PowerPoint Slides. The PBBG and CBG were treated as experimental teaching methods in the Science classroom. The duration of CT, PBBG and CBG were conducted during the school holidays and after regular school hours. Each teaching method covered three topics during three weeks duration, such as "Properties of Light", "Energy", and "Materials", aligned with the Year 4 Science Syllabus. During this process, 574 participants were exposed to three distinct teaching methods.

Before the experiment started, all 10-year-old participants were given a pre-test that covered the three Science topics. This pre-test established a baseline for the participant's performance in this research. A total of 166 participants were exposed to CT in Science classrooms. A post-test was administered after the CT sessions to evaluate the participant's academic performance on the aforementioned topics.

Subsequently, 204 research participants were assigned to learn the three Year 4 Science topics through the implementation of PBBG. Similar to the CT method, a pre-test

was conducted before the PBBG sessions began. The participants were then exposed to PBBG for three weeks, after which they underwent a post-test to assess their understanding of the topics taught using PBBG.

Another 204 participants were exposed to CBG after a pre-test was administered. The teaching process using CBG spanned three weeks, after which a post-test was conducted to examine the participants' academic performance thoroughly.

During the implementation of PBBG and CBG in the Science classroom, the participants were divided into groups of four members each. Consequently, 51 groups applied PBBG and another 51 utilized CBG, emphasising CL. These classroom settings were aligned with the MOE's focus on the 21st-century classroom approaches.

This research aimed to investigate the effectiveness of PBBG and CBG in the Science classroom, particularly focusing on CL among 10-year-old participants. Furthermore, the research explored the participants' perceptions of using PBBG and CBG through CL activities. Moreover, to gather quantitative data, the CT, PBBG and CBG implementation participants were given a questionnaire to provide feedback on the teaching methods at different times. Additionally, qualitative data were obtained through classroom observation and interviews for PBBG and CBG groups.

4.3 Populations and Sampling

The sampling employed in this research was purposive, as the researcher specifically selected 10-year-old participants who aligned with the research objectives. Etikan et al. (2016) noted that purposive sampling involves selecting participants who meet the research objectives. The research was conducted in a tuition centre in Sibu, where a

classroom was rented for three months. The target population for generalizing the research's results was National-Type Chinese Primary Schools participants who studied Science as a compulsory subject in the classroom. All participants were ten years old and attended different National-Type Chinese Primary Schools.

Before the research started, the participants were familiarized with electronic devices and performed online tasks to ensure their proficiency in using the device independently. This preparation aimed to avoid potential issues during CL in the classroom using CBG.

A brief interview was conducted to finalize the sampling process among the 10-year-old participants. According to Alharthi (2020), a preliminary criterion was established to select participants with a positive attitude towards technology usage, enhancing the likelihood of successful completion of collaborative activities. Additionally, the selected participants were required to possess a positive attitude towards their academic studies to ensure motivation throughout the research and their experience in using electronic devices to access the Google Sheet. However, due to the higher percentage of male participants in the 10-year-old population, achieving a gender balance between male and female participants was not feasible. The application of this criterion in the current research may affect the generalization of findings. Since participants were selected based on specific criteria related to technology usage and academic motivation, the findings may not be fully representative of the broader population of 10-year-old participants. The lack of gender balance could also impact the generalizability of the findings, as gender differences may influence attitudes towards technology and academic studies. Therefore, while the findings of the research may provide valuable insights, caution should be exercised when extrapolating them to other populations.

This section also provides an overview of the participants' demographics in the three teaching methods. The participants came from diverse educational backgrounds, including Chinese, Malay and Iban. The Science subjects were taught in the Mandarin language.

The CT method was applied to 166 participants taught using PowerPoint presentations. Table 4.1 presents the gender distribution of the participants exposed to the CT methods in this research.

Table 4.1: Gender Distribution of 10-year-old participants who were exposed to PowerPoint Presentation

Male Participants		**Female Participants**	
Number of Respondents	**Percentage**	**Number of Respondents**	**Percentage**
57	**34.3 %**	**109**	**65.7%**

According to Table 4.1, a total of 57 male participants (34.3%) and 109 female participants (65.7%) voluntarily engaged in learning three topics: "Properties of Light", "Energy", and "Materials" through PowerPoint presentations. In fact, CT groups were arranged to attend the class on Saturdays and Sundays from 1st March 2023 till 15th May 2023. There were six classes per day for them to learn those topics, as the duration is 1 hour per session. Those sessions were 9:30 a.m. till 10:30 a.m.; 11:00 a.m. till 12.00 p.m.; 2:00 p.m. till 3:00 p.m.; 3:30 p.m. till 4:30 p.m.; 5:00 p.m. till 6:00 p.m. and 7:00 p.m. till 8:00 p.m. Those participants attended the class when they were free and ready to learn until all three science topics were completed.

Similarly, Table 4.2 illustrates the gender distribution of the participants who willingly participated in the groups utilizing PBBG with CL in the classroom.

Table 4.2: Gender Distribution of 10-year-old participants who were exposed to PBBG with CL.

Male Participants		**Female Participants**	
Number of Respondents	**Percentage**	**Number of Respondents**	**Percentage**
66	**32.4 %**	**138**	**67.6%**

Referring to Table 4.2, 66 male participants (32.4%) and 138 female participants (67.6%) voluntarily learned three topics by applying PBBG with CL during the research. Similar with CT groups, the period for implementing the PBBG was from 1st March 2023 till 15th May 2023, on Mondays till Fridays only. Nine sessions have been conducted per day during the school holidays, such as 8:00 a.m. till 9:00 a.m.; 9:30 a.m. till 10:30 a.m.; 11:00 a.m. till 12.00 p.m.; 12:30 p.m. till 1:30 p.m.; 2:00 p.m. till 3:00 p.m.; 3:30 p.m. till 4:30 p.m.; 5:00 p.m. till 6:00 p.m.; 6:30 p.m. till 7:30 p.m. and 8:00 p.m. till 9.p.m. However, there were only four sessions per day during the schooling days. Those 10-yaer-old participants attended the class voluntarily, choosing times when they were available and eager to learn, until they had completed all three science topics.

Additionally, a total of 204 participants willingly participated in the implementation of CBG with CL in the Science classrooms. Table 4.3 presents the gender distribution of the participants utilizing CBG with CL.

Table 4.3: Gender Distribution of 10-year-old participants who were exposed to CBG with CL

Male Participants		Female Participants	
Number of Respondents	**Percentage**	**Number of Respondents**	**Percentage**
63	**30.9 %**	**141**	**69.1%**

According to Table 4.3, 63 male participants (30.9%) and 141 female participants (69.1%) selected and willingly participated in CBG with CL. The topics covered in CBG were similar to those taught using CT and PBBG with CL. Similar to the PBBG groups, CBG implementation took place from March 1st, 2023, to May 15th, 2023, exclusively on weekdays. During school holidays, nine sessions were conducted each day, ranging from 8:00 a.m. to 9:00 p.m., while on regular school days, only four sessions were held. The 10-year-old participants voluntarily attended the sessions at their preferred times, demonstrating their readiness and enthusiasm to learn until all three science topics were covered.

The participants were arranged to learn three specific topics with each teaching method: CT, PBBG and CBG. Each topic was allocated one week as planned, ensuring that the three topics were taught at different times during the research. This arrangement was likely implemented to ensure that the impact of each teaching method could be assessed across the same three topics without any potential bias from the order of topics being taught. Meanwhile, each teaching method is applied to those three topics at different times allows for a fair comparison of their effectiveness. Same topics may require different instructional approaches for respective groups (CT, PBBG and CBG), as it helps to ensure

that each teaching method has the opportunity to demonstrate its efficacy across science learning.

4.4 Ethical Considerations

The researcher must adhere to ethical principles to maintain an impartial position, honesty and respect for the integrity, will and privacy of individuals participating in the research process. In this regard, the researcher sought approval from the Human Research Ethics Committee, University Malaysia Sarawak (UNIMAS) to ensure ethical research involving human subjects.

Furthermore, the researcher needed authorization from the relevant school district, such as the Sibu District Education Office, to conduct this research. Before the research started, several ethical issues were addressed to ensure the safety and well-being of the participants. Hence, this specific training was planned and conducted for one week, starting from 20th February 2023 till 26 February 2023. This section described how these ethical concerns were addressed to safeguard the participants involved in this research.

4.4.1 Informed Consent

Obtaining informed consent was an ethical and legal requirement in research, as it ensured that participants voluntarily agreed to participate in this research. Informed consent involves providing participants with a clear understanding of what will occur throughout the research, including their rights and responsibilities.

Additionally, it was crucial to prioritize the protection of human subjects who participated in this research and ensure the confidentiality of their personal information,

such as their name and family background. This information should be encrypted and kept confidential to maintain privacy and confidentiality (Gerard et al., 2022).

4.4.1.1 Informed Consent: Students

Several measures were implemented in this research to ensure informed consent. Firstly, an information sheet was provided to the participants, outlining the research's nature, roles, and expectations. The information sheet also clearly stated the purpose of the research, including the relationship between the application of PBBG and CBG, with CL and its impact on academic performance, motivation and social interaction in learning Science. The information sheet also explains the key research objectives and data-gathering process (Mayya et al., 2022).

Participants were informed that the research was part of the researcher's Doctor of Philosophy Degree Program and would benefit his teaching practice in Science education. Also, the information sheet is presented in plain language, ensuring clarity and comprehension. Participants were informed of their roles in the research, including their involvement in individual and semi-structured interviews related to their questionnaire responses during the post-task walkthrough (Taherdoost, 2022).

Importantly, the participation of the 10-year-old participants was voluntary, and they had the right to withdraw from the research at any stage. The choice to participate was communicated to participants verbally and non-verbally, and they were informed that there were no negative consequences for non-participation. Participants had to sign a consent form attached to the information sheet, indicating their agreement to participate and allowing the researcher to use their data. The information sheet also assured participants

that their confidentiality would be safeguarded; collected data would be treated with full confidentiality. Pseudonyms, such as 'PBBG G1P1', were used to protect the participants' identities, and no identifying information was used. The information sheet provided the contact details of the researcher, research supervisor and the Human Research Ethics Committee Office, University Malaysia Sarawak (UNIMAS). Participants were given enough time to read the information sheet and ask questions before proceeding with the questionnaires, classroom observation, and interview.

After providing the participant with the information sheet, a separate consent form was provided at the back of the sheet. By signing the consent form, the participants acknowledged that they had received and understood the participation information sheet, including the important statements, such as the purpose and procedures of the pilot study and research, the voluntary nature of their involvement, their right to withdraw at any time, the non-use of personal information in published materials. They could decide whether it was used in secure information storage for a specified period.

Additional information sheet and consent forms were provided for participants in the interview session. This information sheet constituted similar information as the previous one, explaining that participants had already completed the survey, and the interview sessions were conducted to gather additional information. It also included details about the interview duration and schedule, and participants were assured that their information remained confidential and removed after the analysis. Contact details for the researcher and the research supervisor were provided, and participants were given time to review the information sheet and ask questions before the interview session started. The consent form was attached at the back of the information sheet. This assumed the

participants agreed that they had been provided with participation information and understood how it worked.

Throughout the research, the researcher prioritized the protection of participants. Participants were divided into groups for pilot-testing PBBG and CBG, with CL and implementing CT, PBBG and CBG in the Science classroom. These measures were taken to ensure the safety and well-being of the participants during the research process.

4.4.1.2 Informed Consent: Parents

When conducting research involving participants under 18, it is necessary to obtain parental consent. Informed consent ensures that the participants' parents were fully informed of the purpose and procedures of the pilot study or the main research, and they understand and agree, in the written format, to their child's participation in the research.

In this research, the researcher used a camera to record the feedback or responses from the participants during the implementation of PBBG and CBG with CL in the Science classroom. The consent form was issued to the parents of research participants to avoid potential controversy. The information sheet clearly explained the use of video recording for classroom observation purposes. Additionally, the information sheet informed the parents that their child might be selected for individual and semi-structured interviews for the main research, specifically for post-task walkthroughs to clarify their responses and feedback while implementing PBBG and CBG with CL in the Science classroom. The parents must sign and return the consent forms before the research can begin. Only those participants whose parents had consented were allowed to participate in the pilot study or main research willingly. Obtaining parental consent is crucial in research involving minors

to ensure that the rights and well-being of the participants are protected and that the research is conducted ethically and with the informed agreement of all involved parties.

4.4.1.3 Application Letter for Conducting the Research to the Selected Tuition Centre

Concerning ethical procedures, the researcher initiated the research process by issuing an application letter to the principal of the selected tuition centre. Once the principal granted permission, a consent letter was prepared outlining the terms and conditions for participation in the pilot study and the main research. It was important to note that all the selected participants were required to use electric devices during the teaching and learning activities in the Science classroom. The participants were informed about using these devices and were allowed to apply them in the classroom, but only with authorization from the researcher. This suggests that the researcher maintained control over the use of electronic devices and ensured that their use was aligned with the research objectives and guidelines.

4.4.2 Privacy and Confidentiality

To ensure privacy and confidentiality, the researcher implemented various measures. One of the ways to address privacy is through anonymity. Hence, all data collected from the participants were assigned to anonymous codes instead of using their names. This coding system was implemented to protect the privacy and confidentiality of participants.

However, during the collection of the test results, the participants were required to provide their names on the papers to match their pre-test and post-test results accurately.

The pre-test paper was securely stored and only accessible to the researcher. After matching the results on the electronic database, the participants' names were removed and replaced with codes to maintain anonymity. The paper copies of the tests were stored in a locked cabinet until the analyses were completed, after which they were destroyed.

In terms of classroom observations, they were screen-recorded using a screen recording method on an electronic device. These recordings were appropriately labelled with class, topic and date for easy identification. The recordings and classroom observation protocols were stored in a locked cabinet during the research to ensure security and confidentiality.

Furthermore, the interviews conducted for post-task walkthroughs were audio recorded and uploaded onto a password-protected computer. The audio files were saved with appropriate file names. Once transcribed, the participants' names were replaced with codes to anonymise the qualitative data. Only the researcher and the supervisor had access to the qualitative information during the analysis stage.

4.4.3 Data Storage

To ensure the security and integrity of the data, hard-copy and electronic data were handled carefully and stored appropriately. The hard-copy data, including paper-based data, questionnaires, classroom observation protocols, interview data, informed consent forms, and pre-test and post-test, were stored in a locked cabinet during the data collection. Once the research was completed, these paper-based data were destroyed were securely destroyed to maintain confidentiality.

The electronic data, such as recordings and transcripts, were kept on the computer and the backup disk. Both of these were password-protected to prevent unauthorized access. Only the researcher and the researcher's supervisor had access to the electronic data during the data analysis stage. The computer was secured to ensure the data's safety and prevent potential loss. Hand-written notes and images were also kept in the locked cabinet along with the completed paper-based questionnaires, classroom observation forms, interview forms, pre-test and post-test papers and informed consent forms.

After the thesis publication date, the raw electronic data were retained for a certain period for review purposes. However, files were securely destroyed after the retention period to maintain confidentiality and protection.

These measures aimed to safeguard the privacy, confidentiality, and integrity of hard-copy and electronic data throughout the research process. By following these procedures, the researcher ensured the proper storage, limited access, and eventual destruction of the data responsibly.

4.4.4 Minimizing Disruption

The researcher took several measures to minimize the disruption and potential harm to the participants. Firstly, all the necessary materials were provided to the participants well in advance, and sufficient time was given to familiarize themselves with them. The pilot study and the main research were conducted during the school holidays to ensure that the normal timetable and programs for 10-year-old participants were not disrupted. In order to avoid any controversial issues, the researcher ensured that the participants had not been exposed to the three selected Science topics before the research. This was done by

selecting topics not part of their Year 3 Science subject syllabus, which they had just completed before school reopened. This helped ensure that the participants approached the research topics with a fresh perspective and minimized potential biases or preconceptions. Furthermore, the researcher and participant agreed upon a suitable time to accommodate both parties for the individual and semi-structured interviews. This ensured that the interview was conducted conveniently for the participants, reducing any inconvenience or disruption to their regular activities.

These measures were implemented to ensure the smooth and ethical progression of the research while minimizing any potential harm or disruption to the participants involved.

4.5 Validity and Reliability

In educational research or studies, various tests were used to ensure the validity and reliability of the findings. These tests included content validity, construct validity, internal validity, external validity and reliability (Piemontese, 2022).

Content validity was the first test and focused on whether the test adequately represents and covers the content domain (Alemayehu et al., 2021). Furthermore, the materials used in the test must be suitable for the curriculum. In addition, content validity indicated that the test must reflect what has been taught and the knowledge the researcher intended to assess. In this research, the researcher ensured content validity by aligning the test with the syllabus and curriculum for Malaysian primary schools, specifically the Revised Standard-Based Curriculum for Primary Schools for 10-year-old participants.

Construct validity involves establishing appropriate operational measures for measuring the underlying concept and ensuring they align with the construct and its operational definition. It was important to note that construct validity can be challenging due to the subjectivity involved, which may affect the selection of operational measures and judgments for data collection. To address this, the researcher conducted a literature review of relevant studies to identify concepts related to the operational measures and ensured consistency with previous research.

This research focused on using CT, PBBG, and CBG with CL in the Science classroom, and the relevant measures included construct validity, internal validity, external validity, and reliability. Construct validity was enhanced using multiple sources of evidence, such as digital textbooks, yearly lesson plans and *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP), all aligned with the teaching objectives in the syllabus for Year 4 pupils in Malaysian primary schools.

Internal was crucial for ensuring the validity of the research findings, particularly in between-group designs. It was associated with controlling the extraneous variables (Slocum et al., 2022), which can potentially influence the research outcomes. Therefore, it was important for the researcher to establish causation and demonstrate that the experimental treatment was responsible for any potential change in the dependent variable.

This research aimed to determine the causal relationship between applying CT, PBBG and CBG with CL and its impact on academic performance, social interaction, and the respondents' learning motivation. To achieve this, the researcher must carefully control for other variables that may influence the relationship being studied. In this research, two experienced Science teachers were invited to review and ensure the validity of the instruments used to measure the internal validity of CT, PBBG, and CBG.

On the other hand, external validity refers to the extent of the generalizability of the study results to a larger population (Parcel, 2022). Random participant selection was recommended to ensure that the research sample was representative of the entire population in the specific setting. Additionally, external validity can be enhanced by including different populations, settings, or periods in the study. In the present study, the focus was on content validity and internal validity. Content validity was established through a judgmental approach involving literature reviews and evaluation by expert judges or panels (Taherdoost, 2016). Furthermore, test-retest reliability was conducted in this research to measure the internal validity.

Reliability in this research refers to the consistency and repeatability of operations to minimize errors or biases. Developing a research database can enhance reliability. In this research, inter-rater reliability was employed to assess the reliability of the data using Cohen Kappa's Inter-rater reliability tests (Dawson & Trapp, 2004), as illustrated in Table 4.4. Two raters judged the research instruments, including the pre-test, post-test, and questionnaire.

Table 4.4: The standards of Cohen Kappa's Inter-rater reliability of the tests

Kappa Values	Interpretation of Level of Agreement
1.00	Perfect agreement
0.93-0.99	Excellent agreement
0.81-0.92	Very good agreement
0.61-0.80	Good agreement
0.41-0.60	Fair/substantial agreement
0.21-0.40	Slight agreement
0.01-0.20	Poor/chance agreement
Less than 0.00	No agreement

Source: Dawson & Trapp (2004)

By employing these validity tests, the researcher can ensure that the assessments accurately measure the intended construct and provide reliable and meaningful data for the research. Furthermore, by addressing internal validity, external validity, and reliability, this research aimed to ensure the robustness and accuracy of its findings.

4.5.1 PowerPoint Presentation Slides

The preparation of PowerPoint Presentation slides and the development of educational materials for CT in this research involved three different topics: "Properties of Light", "Energy", and "Material". The researcher referred to DSKP for Year 4 Science from the Revised Standard-Based Curriculum for Primary School as a guide provided by the Ministry of Education (MOE, 2018). Each topic was aligned with specific content standards. For instance, the topic "Properties of Light" included three content standards such as "Light Travels in a Straight Line" (p.56), "Reflection of Light" (p.57) and "Refraction of Light" (p.58).

The topic "Energy" consisted of two main content standards: "Sources and Forms of Energy" (p.61) and "Renewable and Non-renewable Energy Sources" (p.62). Finally, the topic "Material" consisted of two important content standards: "Basic Sources of Materials" (p.64) and "Properties of Materials" (p.65). Each content standard was supported by various learning standards specified in the Year 4 Science Curriculum and Assessment Standards Document.

The PowerPoint Slides were prepared in Mandarin, commonly used in Year 4 Science classrooms for National-Type Chinese Primary Schools. Additionally, the researcher incorporated a video with audio, suitable images and animations into the

PowerPoint slides to enhance the learning experience. To ensure accuracy, the researcher collaborated with other Science teachers who are experts in the subject matter. This collaborative discussion aimed to eliminate any mistakes in contents, notes and modules during the PowerPoint presentations. Examples of these PowerPoint Slides used in this research were provided [**Appendix A**].

4.5.2 Paper-Based Board Games (PBBG)

The board games used in research encompassed various designs, depending on the researcher's approach (Karasimos, 2021). In this research, the PBBG was developed as an educational board game that can be played on a table. All the physical components of the game were packed in a cardboard box. The game included essential features such as dice, cards, board, and board game rules. These elements align with the objectives of teaching participants facts and information about specific topics in the Year 4 Science subject syllabus.

Furthermore, to ensure the quality of the questions in the PBBG, the researcher incorporated HOTs elements, considering that many pupils may struggle to answer such questions. Additionally, questions of varying difficulty levels (easy, moderate and hard) were evenly distributed throughout the game. This allowed participants to choose questions, attempt to answer them, and learn through the provided explanations engagingly and enjoyably.

The internal validity of the PBBG was tested by instructing a few volunteers to play the game in an undisturbed setting. Additionally, to minimise the influence of confounding factors, such as strain or exhaustion resulting from playing PBBG, the volunteers were

asked to complete one full level of the game twice, with at least a 30-minute rest period. This approach helped ensure that external factors did not affect the test-retest results and provided a reliable internal validity measure. Examples of these PBBGs used in this research were provided [**Appendix B**].

4.5.3 Computerized Board Games (CBG)

In line with the recent trends in Science and technology, this research incorporated the use of CBG. CBG shared many similarities with other digital games that involved electronic devices. In addition, CBG was a game that must be non-static and played digitally. Furthermore, CBG had similar components and features to PBBG, such as games, pieces, and markers, followed by rules to be followed by the participants.

In this research, it was crucial to ensure that the contents of the CBG aligned with the current syllabus of the Year 4 Science Subject. Therefore, similar to PBBG, the researcher focused on three Science topics: Properties of Light, Energy and Material. In addition, the questions, notes or modules in the CBG were designed to be relevant to the questions provided in the pre-test. This approach allowed participants to concentrate on the Science topic and attempt to answer the questions, incorporating HOTs elements using electronic devices in the classroom. Examples of these PBBGs used in this research were provided [**Appendix C**].

4.5.4 Pre-Test and Post-Test

In this research, the researcher prepared a pre-test and a post-test for three groups of 10-year-old participants from National-Type Chinese Primary Schools, using identical

questions for both tests. After participants answered the questions in the pre-test, the researcher collected and analyzed the responses without returning the papers to them, keeping the results undisclosed. It was conducted to avoid any potential controversy of memorizing the answers accidentally among the participants during post-test administration. Then, each teaching method was implemented for three consecutive weeks, including PowerPoint presentation, PBBG and CBG. After this period, a post-test was administered again to evaluate the effectiveness of PBBG and CBG with collaboration, which served as a treatment in this research, and PowerPoint Presentation slides were assumed as CT.

The questions provided in the pre-test and post-test were carefully designed to align with the requirements of DSKP for the Year 4 Science subject. Additionally, these tests were constructed based on the Table of Specification (TOS), which functions as a test blueprint table, assisting teachers in aligning objectives, instructions and assessments. The TOS helped the researcher to determine the distribution of items across different cells in the table, considering the relative importance of each component of the syllabus and each level of the cognitive domain. By following the TOS, the researcher aimed to enhance the validity of the evaluation in the pre-test and post-test, as suggested by Alemayehu (2022). The evaluation of items based on TOS reflects the distribution of three key cognitive levels with respective percentages: Knowledge (50%), Understanding (30%) and Thinking (20%) (Alade & Omoruyi, 2014).

To measure the validity and reliability of the tests, two highly experienced Science teachers were invited to review and discuss both pre-test and post-test. They carefully examined each item and provided their using a 5-point Likert Scale for both multiple-

choice and open-ended formats [**Appendix D**]. Their expertise and input were valuable in ensuring the quality of the assessments.

Once the researcher has collected the data, an inter-rater reliability test using Cohen Kappa's was conducted to assess the level of agreement between the two teachers, as illustrated in Table 4.4. In the analysis, a Kappa value of more than 0.93 indicates excellent agreement beyond chance. A Kappa value between 0.61 and 0.80 indicates good agreement beyond chance. If the Kappa value is lower than 0.20, it suggests poor agreement beyond chance, and the items or questions must be replaced.

According to the frequencies in Table 4.5, 107 pre-test and post-test questions exhibited no classification discrepancy between Teacher A and B. This suggests 92.2% agreement or a Kappa value of 0.922 between the two teachers. The Kappa value of 0.922 indicates a very good agreement, as it falls within the range of 0.81 and 0.92. Therefore, based on the high agreement between Teachers A and B in classifying the questions, the inter-rater reliability test indicates a strong level of agreement in their assessment.

Table 4.5: Frequency and Percentages for Teacher A and Teacher B in Rating the Questions from Both Pre-test and Post-test

Questions	**Frequency**	**Percentage (%)**
Same Agreement	107	92.2
Different Agreement	9	7.8
Total	**116**	**100**

4.5.5 Questionnaire

The research questionnaire used in this research consists of two main sections: Learning Motivation and Social Interaction. The Learning Motivation section was based on the work of Pintrich et al. (1991) and Sousa et al. (2017), while the Social Interaction

section was adapted from Högberg et al. (2019). These sections have been sourced from different references and adapted for this research.

The questionnaire was translated into Mandarin to make it accessible to 10-year-old National-Type Chinese Primary Schools participants. In order to ensure the validity and reliability of the translated questionnaires for both PBBG and CBG, two experienced Mandarin teachers were invited to review and discuss each item. They worked together to choose the most appropriate options for the evaluation form, which utilized a 5-point Likert Scale. The details of the evaluation form can be found in **Appendix E**.

The involvement of experienced Mandarin teachers in the translation and evaluation process contributes to the overall validity and reliability of the questionnaire. The expertise ensures that the language used is accurate and appropriate for 10-year-old participants, allowing for meaningful responses in the research context, as shown in **Appendix F**.

After collecting data from the two experienced teachers who evaluated the questionnaires, the researcher conducted a Cohen Kappa's inter-rater reliability test to assess the level of agreement between the teachers.

Based on the frequency Table 4.6, it can be observed that out of 31 items, 30 items achieved the same agreement between Teacher A and Teacher B. This corresponds to an agreement of 96.8% or a kappa value of 0.968 for the questionnaire administration. As the Kappa value exceeds the excellent agreement (>0.93), it can be concluded that the teachers have a high level of agreement in evaluating the questionnaires. This indicates that the questionnaires were administered consistently and reliably, enhancing the study's overall validity, as shown in Table 4.6.

Table 4.6: Frequency and Percentages for Teacher A and Teacher B in Rating the Questionnaires

Questions	**Frequency**	**Percentage (%)**
Same Agreement	30	96.8
Different Agreement	1	3.2
Total	**31**	**100**

4.5.6 Classroom Observation Protocol

In this research, the classroom observation protocol was adapted from Swaran Singh et al. (2017) and used to collect data related to the learning motivation and social interaction features among the 10-year-old participants from National-Type Chinese Primary Schools during the implementation of PBBG and CBG in the Science classroom. Before the research started, the researcher collaborated with a non-participant observer, an experienced teacher in the Professional Learning Community (PLC), for more than seven years in different schools. PLC is a strategy that promotes knowledge sharing and professional development among teachers and staff members. One of the dimensions of the PLC is "Shared Personal Practice" (Hassan et al., 2022), which allows teachers to exchange ideas and observe each other's teaching practices. Through this collaboration, the teachers provided insights and feedback on the observation technique while implementing PBBG and CBG in the Science classroom. The classroom observation protocol was selected based on its relevance to the research objectives and the recording of learning motivation and social interaction features.

The frequencies in Table 4.7 indicate a complete agreement among all sections of the classroom observation notes. This results in 100% agreement or a Kappa value of 1.00, which indicates a perfect agreement between the observer and researcher. This high level of agreement enhances the reliability and validity of the classroom observation data,

reinforcing the credibility of the study's findings related to learning motivation and social interaction.

Table 4.7: Frequency and Percentages for Teacher A and Teacher B in Rating the Classroom Observation Protocol

Sections	Frequency	Percentage (%)
Same Agreement	5	100
Different Agreement	0	0
Total	**5**	**100**

4.5.7 Interview Protocol

This research conducted individual and semi-structured interviews with 10-year-old participants following the classroom observation phase. The interviews aimed to gather participant feedback and responses, and audio recordings were made to ensure comprehensive data analysis. The researcher ensured that the interview questions were closely aligned with the statements in the questionnaire, focusing on the research objectives related to learning motivation and social interaction features. Furthermore, post-task walkthroughs are also implemented.

The interview protocol consisted of 20 questions provided in English and Mandarin versions. Recognizing the participants' level of understanding as 10-year-old participants, the researcher translated the questions into plain language to facilitate comprehension. Two Science teachers were invited to review and assess the interview protocol for PBBG and CBG implementations, ensuring that the translated language was suitable for 10-year-old participants. The interview questions were cross-referenced with the statement from the questionnaire instrument in **Appendix G**.

The involvement of experienced Mandarin teachers in the translation and evaluation process contributed to the overall validity and reliability of the interview. The expertise ensured that the language used was accurate and appropriate for 10-year-old participants, allowing for meaningful responses in the study context. Participants were asked to select the best option using a 5-point Likert Scale to evaluate the interview protocol related to CBG implementation. The details of the evaluation form can be found in **Appendix H**.

A Cohen Kappa's inter-rater reliability test was conducted to assess the agreement between the Science teachers regarding the interview questions for implementing PBBG and CBG. This test followed established standards. The frequency analysis presented in Table 4.8 demonstrated a remarkable level of agreement between the raters. The results indicated 90% agreement or a Kappa value of 0.900 when referring to the interview protocol before conducting the pilot study. This outcome suggests that a very good agreement enhances the reliability and validity of the interview data and strengthens the credibility of the findings related to learning motivations and social interaction.

Table 4.8: Frequency and Percentages for Teacher A and Teacher B in Rating the Interview Protocol

Sections	**Frequency**	**Percentage (%)**
Same Agreement	18	90
Different Agreement	2	10
Total	**20**	**100**

4.6 Research Instruments

This research collected quantitative and qualitative data to examine the impact of CBG and PBBG on the participants' academic achievement, motivation, and social

interaction in learning Science. Four instruments were utilized to gather necessary data: CBG, PBBG, pre-test and post-test, questionnaire, classroom observation protocol and interview protocol.

4.6.1 Computerized Board Games (CBG)

The name of CBG used in this research was named *SciFun Board Game*. The *SciFun Board Game* focused on the three selected topics, "Properties of Light" from Chapter 5 and "Energy" from Chapter 7 and "Material" from Chapter 8. These topics fell under the overarching themes of "Materials Science" and “Physics Science”. The CBG consisted of four rows, each containing five subsections. Each subsection had five questions for each participant to answer during their turn while playing the game. The questions in the *SciFun Board Game* were designed in two formats: multiple-choice and open-ended, along with corresponding explanations. The researcher included HOTs questions in the *SciFun Board Game* to stimulate higher thinking skills among the participants. To play the CBG, the participants used electronic devices, specifically notebooks. They interacted with the game by clicking on icons correctly to provide their answers. The duration for playing *SciFun Board Games* under the researcher's supervision in the Science classroom was approximately 30 minutes.

The *SciFun Board Games* was an engaging and interactive method for assessing the participants' understanding of the selected Science topics. Its incorporation of technology and various question formats aimed to enhance the participants’ learning experience and stimulate HOTs.

4.6.2 Paper-Based Board Games (PBBG)

The PBBG used in this research was also called *SciFun Board Game,* similar to CBG. However, there were some differences in how the PBBG was played. In the PBBG version, the research participants were given a physical board game consisting of four rows, each containing five subsections. Like in the CBG, five questions were allocated to each subsection. The format of the questions was the same as in CBG, with multiple-choice and open-ended formats accompanied by explanations. The selected topics for the questions were the same as in the CBG, ensuring that they included HOTs elements to encourage critical thinking among the participants. Unlike the CBG, played digitally on electronic devices, the PBBG was played non-digitally using the physical board games provided to each participant. The researcher supervised the participants during the PBBG session, ensuring they had a quiet and uninterrupted environment to focus on playing the game. The PBBG session lasted for approximately 30 minutes, allowing sufficient time for the participants to engage with the game and answer the questions. The researcher's role was to oversee the participants' progress and provide any necessary support or clarification during the gameplay in the Science classroom. The inclusion of the PBBG as a research instrument provided an alternative method for assessing the participants' understanding of the Science topics. Furthermore, offering a hands-on and non-digital experience aimed to provide a different learning experience and promote active participant engagement.

4.6.3 Pre-test and Post-test

A pre-test was conducted in this research to assess certain attributes or characteristics of the participants before the treatment or intervention took place. Its

purpose was to establish participants' proficiency levels before the treatment. The pre-test was administered to experimental and control groups before the treatment was implemented. Following the treatment, a post-test was conducted to measure changes or effects on the participants' attributes or characteristics. It served as a means to evaluate the effectiveness of the treatments or interventions on the participants' proficiency levels. The post-test was administered after the experimental and control groups had received the treatment.

The use of pre-tests and post-tests was a common practice in research to assess the outcomes of interest and evaluate the impact of the intervention. By comparing the pre-test and post-test results, the researcher could gain insight into the effectiveness of instructional strategies and interventions to improve student learning.

In this research, the pre-test [**Appendix I]** and the post-test **[Appendix J**] consisted of 60 multiple-choice and 12 open-ended questions. These questions were based on the three selected topics: properties of light, energy, and material, which were part of the Year 4 Science curriculum. The questions were designed based on the revised Standard-Based Curriculum for Primary Schools set by the Malaysia National Curriculum. To ensure the quality of the test items, the researcher collaborated with two experienced Science teachers who provided valuable input and suggestions.

In response to the teachers' feedback, some modifications were made to the pre-test [**Appendix K]** and post-test [**Appendix L]**. Specifically, the test was categorized into different levels, such as easy/knowledge (30%), moderate/understanding (50%) and hard/thinking (20%). Additionally, questions with HOTs were highlighted to assess the participants' critical thinking and problem-solving abilities.

The Science teachers provided valuable recommendations regarding the questions included in the pre-test and post-test. They suggested that the questions reference information from the exercise book, including the publisher, book names, and main features. The questions were aligned with the Year 4 textbook and Curriculum and Assessment Standards Document, with publishers such as *PA*, *PEP* and *CEMERLANG*. Additionally, various exercise books were used, such as *Buku Aktiviti Sains 4A; Buku Aktiviti Sains 4B,Buku Aktiviti Skills Tahun 4; Tes Topikal Arif Sains Tahun 4; Latihan Lengkap Unit Sains Tahun 4 4A; Latihan Lengkap Unit Sains Tahun 4 4B; Pentaksiran Bilik Darjah Refleksi Pentaksiran Cemerlang SJKC Sains Tahun 4; Latihan Pengukuhan Cemerlang SJKC Sains 4A; Latihan Pengukuhan Cemerlang SJKC Sains 4B; Siri Praktis Topikal Cemerlang SJKC Sains Tahun 4; Praktis Dinamik Cemerlang SJKC 4A and Praktis Dinamik Cemerlang SJKC 4B*.

Furthermore, the Science teachers recommended categorizing the questions with subtopics, allowing participants to understand the scope directly. They also suggested that the learning and performance standards should be listed to determine the question level. Additionally, they proposed the inclusion of i-THINK maps for the questions in Section B. Overall, the teachers found the questions and formats to be satisfactory, but they recommended preparing an answer scheme with an explanation for Section A.

An inter-rater reliability test was conducted for each section of the three selected topics for the pre-test and post-test to ensure the reliability of the test. The results of the reliability test, shown in Table 4.9, were evaluated using Cronbach's alpha. For the "Properties of Light" topic, Section A agreed well with Cronbach's alpha of 0.733, while Section B indicated perfect agreement with a value of 1.000. In the "Energy" topic, Section A reached a very good agreement with Cronbach’s alpha of 0.857, and Section Breached a

perfect agreement with Cronbach's alpha of 1.000. Regarding the "Material", Section A obtained good agreement with Cronbach's alpha of 0.762, while Section showed a fair agreement with a value of 0.474. The *p-value* of all sections in the three selected Science topics was less than 0.05, indicating that the levels of agreement significantly differed from what would be achieved by chance.

Table 4.9: Results of Reliability Test toward Three Science Topics for Pre-Test and Post-test

Variables	Number of Items	Number of Removed Items	Cronbach's Alpha	*p-value*
Topic: Properties of Light				
Section A	20	0	.733	.001
Section B	20	2	1.000	.000
Topic: Energy				
Section A	20	0	.857	.000
Section B	20	3	1.000	.000
Topic: Material				
Section A	20	0	.762	.001
Section B	20	0	.474	.028
Table 4.9 Continued				
Original Total of Items				**115**
New Total of Items				**110**

Several items, such as No. 14 and No. 15 for Section A in the topic "Properties of Light" and No.1 (b) (i), No.1b (ii) and No.3 (a)(ii) for Section B in the topic "Material", were removed from the questionnaire due to cross loading. By eliminating these items, the researcher aimed to increase the reliability and trustworthiness of the remaining items in each test section. Consequently, a finalized version of the pre-test **[Appendix M**] and post-test **[Appendix N**] was prepared for this research later.

4.6.4 Questionnaire

The questionnaire, commonly known as a survey, is a crucial tool for gathering data from participants in academic research. It plays a significant role in collecting primary and quantitative data, allowing for a standardized and comparable data collection process (Creswell & Hirose, 2019). Questionnaires enable faster and more accurate data collection, streamlining the data processing stage.

In this research, the questionnaire design addressed the research objectives outlined in Chapter 1. Closed-ended questions were predominantly used, as supported by Taherdoost (2022), who emphasized the prevalence of closed-ended question format in contemporary research. However, it is essential to the scaling method, such as the Likert scale, as different researchers suggest different alternatives. While a 7-point scale may enhance responses differentiation and reliability compared to a 5-point scale (Taherdoost, 2019), a smaller number of points, such as a 5-point scale, may be more suitable (Lietz, 2010). The content of the questions themselves can influence the choice of the number of points. By incorporating the questionnaire as a data collection instrument, this research aimed to effectively address research questions, allowing for a focused exploration of problems or uncertainties without being constrained by assumptions.

In this research, two sets of questionnaires were developed, each consisting of 45 items and were divided into three main parts to assess the impact of implementing PBBG [**Appendix O**] and CBG [**Appendix P**] in the Science classroom. Part A of the questionnaire aimed to gather demographic information from the participants. It included five items related to age, class, gender, race and religion.

Part B of the questionnaire focused on the participants' motivation to apply PBBG and CBG, with CL in the Science classroom. This section was adapted from the Motivated Strategies for Learning Questionnaire (MSLQ) Manual. The MSLQ consists of two main sections: the motivation section contains 31 items assessing participants' goals, value beliefs, beliefs about their skills and anxiety related to test performance. The learning strategy section also included 31 items measuring participants' use of different cognitive and metacognitive strategies and 19 on managing different resources. The original MSLQ was developed by Pintrich et al. (1991) for college students, but it was adapted for this research to suit 10-year-old participants from National-Type Chinese Primary Schools. The adapted version included 31 items from the motivation section, modified to align with the research objectives. The response options for each statement were simplified into five options: "1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree" (Sousa et al., 2017).

An overview of the variables or items altered by the researcher from the original MSLQ Manual by Pintrich et al. (1991) has been prepared. These modifications ensured that the questionnaire was suitable for assessing learning motivation after implementing PBBG [**Appendix Q**] and CBG [**Appendix R**] in this research context.

Part C of the questionnaire focused on 10-year-old participants' social interaction after implementing PBBG and CBG with CL in the Science classroom. This section was adopted from the Gameful Experience Questionnaire developed by Högberg et al. (2019). The original questionnaire consisted of seven dimensions with respective items: Accomplishment (9 items), Challenge (9 items), Competition (8 items), Guided (9 items), Immersion (11 items), Playfulness (10 items) and Social Experience (9 items).

For this research, only the 'Social Experience' from the dimension of the Gameful Experience Questionnaire was included in Part C. The researcher rephrased the items to ensure that 10-year-old participants could understand the statement, considering that the original questionnaire was developed for adult workers (Freire, 2016). Each statement in Part C was rated using a five-point scale: "1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree and 5 = Strongly Disagree".

Information on the variables or items that were altered by the researcher from the original Gameful Experience Questionnaire by Högberg et al. (2019) has been focused on. These modifications aligned the questionnaire with the criteria for assessing social interaction after implementing PBBG and CBG [**Appendix S**] in this research context.

After discussion with two experienced Science teachers, modifications were made to certain parts of the questionnaire for PBBG implementation [**Appendix T**] and CBG implementation [**Appendix U**]. The teacher's feedback led to modifying two items, while the remaining 29 items were maintained. The revised questionnaire versions were developed based on the teachers' input.

In the "Learning Motivation" of Section A, it was decided to categorise the 31 items into dimensions, such as Self-Challenge, Self-Confidence, Assessments, and Learning Motivation, after considering the teachers' opinions. Teacher Ling emphasized the importance of self-challenge in expanding students' thinking and fostering their desire to learn Science. Teacher Koh highlighted the significance of self-confidence in enhancing learning motivation, as students' engagement with their preferred teaching methods can lead to improvements and increased motivation in the Science classroom. Based on these considerations, the items in Section A were categorized as follows: two items under self-

challenge, six items under self-confidence, 13 items under assessment and ten items under learning motivation.

The revised questionnaire for the learning motivation part specifically focused on implementing PBBG, incorporating the modification has been presented based on the feedback provided by the two experienced Science teachers [**Appendix V**].

A discussed version of the questionnaire for the learning motivation part in implementing CBG after modification has been provided based on the comments given by two experienced Science teachers [**Appendix W**].

Meanwhile, only one item, Item 3, must be replaced as it was reductant with Item 5. Then, the remaining items were decided to be maintained. The discussed version of the questionnaire for the social interaction part in implementing PBBG and CBG separately after modification was prepared based on the comments given by two experienced Science teachers [**Appendix X**].

The same inter-rater reliability test was conducted as in the pre-test and post-test for the reliability assessment of the questionnaire instruments. Table 4.10 shows the reliability test result, focusing on Learning Motivation and Social Interaction.

The questionnaire achieved a Cronbach's alpha coefficient of 0.936 in the Learning Motivation part, indicating excellent agreement between the two experienced Science teachers. This high value suggests that the instrument is reliable and consistent in measuring learning motivation. Regarding the Social Interaction part, a Cronbach's alpha coefficient of 1.000 was obtained, representing perfect agreement during the discussion. This indicates that the instrument is highly reliable in assessing social interaction. Overall, the *p-value* for the Learning Motivation and Social Interaction parts was less than 0.05,

indicating that the agreement levels observed in the reliability test differed significantly from what would be expected by chance.

Table 4.10: Results of Reliability Test toward Learning Motivation and Social Interaction in the Questionnaire Instruments

Variables	Number of Items	Number of Removed Items	Cronbach's Alpha	*p-value*
Learning Motivation	31	0	.936	.000
Social Interaction	9	0	1.000	.003
Original Total of Items				**40**
New Total of Items				**40**

4.6.5 Class Observation

Classroom observation was chosen as one of the main methods for collecting data in this research, while qualitative data can be thematically analyzed (Farani & Ma'rufah, 2022). Observational research is widely used in educational research for qualitative inquiries and can be categorized into structured, semi-structured and unstructured observation, participant observation, non-participant observation, direct observation and indirect observation (Alkhadli, 2019).

In this research, the Classroom Observation Protocol, developed by Swaran Singh et al. (2017), was used as a data collection tool to assess 10-year-old participants' learning motivation and social interaction in response to the research questions. The protocol comprised two major domains: Section A for collecting demographic information and Section B for recording observation notes. Although the instrument was originally developed by Can and Silman-Karanfil (2022) for students in Malaysian higher learning institutions, it was adapted for collecting qualitative data in this research after

implementing PBBG [**Appendix Y**] and CBG with CL [**Appendix Z**] among 10-year-old participants separately.

Social interaction and the classroom context are inherently intertwined and cannot be separated. This makes classroom observation a suitable method for obtaining realistic data collection, allowing the researcher to understand what is happening, who is involved, where and when things occur, and the social interaction among the participants in a specific context (Malekshahi, 2019).

In this research, non-participant observation was chosen over participant observation due to its better reliability and the specific objectives of the research, which were to obtain information about social interaction features and the extent of learning motivation among 10-year-old participants during the implementation of CBG with CL in the Science classroom. Through persistent observations, the researcher captured how participants interacted with their surroundings and gained deeper insights into their behaviour and engagement. In addition, a screen recorder was utilized to record all the feedback and contents discussed by the participants in the classroom. This additional tool helped capture detailed information and contributed to the accuracy of data collection.

During the research, the researcher and the teacher involved in the study referred to the guidelines from the latest version of the PLC, where an observation form was one of the tools used in the classroom. After thorough discussion, it was determined that no modification was necessary for this instrument, as it was deemed suitable for the classroom context.

4.6.6 Interview

A qualitative interview is a commonly used method in educational research for collecting data through verbal interaction between the interviewer and the interviewee. Interviews allow researchers to explore participants' experiences, opinions and beliefs toward implementing specific teaching and learning methods, providing in-depth explanations that cannot be achieved through the quantitative method alone (Almeida et al., 2017).

Interviews can be categorized into structured, semi-structured, and unstructured formats, with semi-structured interviews being the most commonly used in qualitative research (Ruslin et al., 2022). In this research, individual and semi-structured interviews were conducted to collect qualitative data. Standardized questions were crucial in maintaining consistency and avoiding bias in the interview process. The interview protocol explored the 'what', 'why' and 'how' aspects of the participants' experiences and perspectives.

This research used a semi-structured interview protocol after implementing PBBG [**Appendix AA**] and CBG [**Appendix AB]**. The interview was conducted face-to-face with each participant individually, lasting approximately 5 to 8 minutes. It was essential to understand the interview process, as it involved three main stages: pre-interview, during, and post-interview. The interviews were conducted in English and Mandarin, depending on their preferred language. Before the researcher conducted the interview, the participants were informed of the details, including the interview's date, time and venue. During the interview, a post-task walkthrough was conducted to clarify any uncertain feedback or responses from the participants related to implementing CBG with CL in the classroom.

Establishing rapport with the participants was important during the interview to encourage open and honest communication (Sun et al., 2020). The researcher followed the interview protocol sequentially, recording using a recorder and taking notes on the participant feedback. Toward the end of the interview, a summary was provided, and participants were allowed to ask questions or offer suggestions.

The collected feedback was analyzed and interpreted during the post-interview stage to uncover any possible new knowledge among the participants. Semi-structured interviews facilitated social interactions between the researcher and the participants, resulting in improved interview techniques and questions that allowed participants to deepen their understanding of the topics covered in the Year 4 Science syllabus.

After discussion with two experienced Science teachers, modifications were made to the interview protocol to better suit research with 10-year-old participants while implementing PBBG and CBG with CL in the classroom. The comments provided by the teachers led to revisions to the three subsections for both PBBG [**Appendix AC**] and CBG implementation [**Appendix AD**].

Specific items were maintained, modified or removed based on the teacher's feedback, resulting in the revised version of the interview protocol (Table 4.11).

Table 4.11 displays the Revised Version of the interview protocol for implementing PBBG, reflecting the modification made based on the comments provided by the two experienced Science teachers.

Table 4.11: Revised Version of the Interview Protocol in Implementing PBBG after Discussion with Two Experienced Science Teachers

NO	VARIABLES / ITEMS	
	Adapted by Researcher	**After Discussion**
1.	Tell me about yourself. 介绍一下你自己。	Tell me about yourself. 介绍一下你自己。
2.	Do you know how to use board games and learn knowledge? 你知道如何使用桌游和学习知识吗?	Do you know how to use board games and learn knowledge before? 在这之前，你知道如何使用桌游和学习知识吗?
3.	Do you enjoy learning Science? Why? 你喜欢学习科学吗？ 为什么?	Do you enjoy learning Science before using Paper-Based Board Games? 在还未使用纸质版桌游之前，你会喜欢学习科学吗?
4.	What do you think about Paper-Based Board Games? 你对纸质版桌游有什么看法?	DELETED as it is similar with No. 5.
5.	Do you think Paper-Based Board Games are new for you? Please give your opinion. 你认为纸质版桌游对你来说是新事物吗？ 请发表你的意见。	Do you think Paper-Based Board Games are new for you? Please give your opinion. 你认为纸质版桌游对你来说是新事物吗？ 请发表你的意见。(No. 5 will be changed to No.4)
6.	Do you understand the content when you learn through Paper-Based Board Games in the classroom? Why? 在课堂上时通过纸质版桌游学习的内容，你是否理解？ 为什么?	Do you better understand the content when you learn through Paper-Based Board Games in the classroom than in the previous lesson? Why? 在课堂上时学习纸质版桌游的内容，和之前的教学活动相比，你是否更加理解呢？ 为什么？(No. 6 will be changed to No.5)
7.	Do you like Paper-Based Board Games to help you figure out what the Science materials are about? Why? 你喜欢纸质版桌游来帮助你弄清楚什么是科学材料吗？ 为什么?	Do you like Paper-Based Board Games to help you determine what the Science materials are about? Why? 你喜欢纸质版桌游来帮助你弄清楚什么是科学材料吗？ 为什么？(No. 7 will be changed to No. 6)

Table 4.11 continued

8.	Do you learn a lot after using Paper-Based Board Games in the classroom? Please give examples. 在课堂上玩纸质版桌游后，你会学到很多吗？ 请举例。	Do you learn a lot after using Paper-Based Board Games in the classroom? Please give examples. 在课堂上玩纸质版桌游后，你会学到很多吗？ 请举例。(No. 8 will be changed to No. 7)
9.	Do you like using Paper-Based Board Games to explain the contents or answer questions? Why? 你喜欢用纸质版桌游解释内容或回答问题吗？ 为什么？	Do you like using Paper-Based Board Games to explain the contents or answer questions? Why? 你喜欢用纸质版桌游解释内容或回答问题吗？ 为什么？ (No. 9 will be changed to No. 8)
10.	Do you like to use Paper-Based Board Games to list their Science materials? Why? 你喜欢用纸质版桌游列出其中的科学资料吗？ 为什么？	Do you like to use Paper-Based Board Games to list their Science materials? Why? 你喜欢用纸质版桌游列出其中的科学资料吗？ 为什么？(No. 10 will be changed to No. 9)
11.	Do you like to work individually or collaboratively? Why? 你喜欢单独还是一起进行活动？ 为什么？	Do you feel motivated to learn Science after implementing Paper-Based Board Games? Why? 实施纸质版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？(No. 16 will be changed to No. 11)
12.	Do you like to use Paper-Based Board Games with your friends? Why? 你喜欢和朋友一起玩纸质版桌游吗？ 为什么？	Are Paper-Based Board Games different from conventional teaching methods? Why? 纸质版桌游与传统教学方法有什么不同？ 为什么？(No. 17 will be changed to No. 12)
13.	Do you like to engage in a group activity to discuss Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？ 为什么？	How often do you learn Science knowledge by implementing educational games like this? 你多久接触到这类的游戏法来学习科学知识？(No. 11 will be changed to No.13)
14.	Do you like to communicate with other group members while you are involved in using Paper-Based Board Games? Why? 在玩纸质版桌游的同时，你喜欢和其他组员交流吗？ 为什么？	Do you like to use Paper-Based Board Games? Why? 你喜欢和朋友一起玩纸质版桌游吗？ 为什么？(No. 12 will be changed to No. 14)

Table 4.11 continued

15.	Do you relate the Science materials with the usage of Paper-Based Board Games? Why? 你是否会将科学材料与纸质版桌游的运用联系起来吗？ 为什么？	Do you like to engage in a group activity to discuss Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？ 为什么？(No. 13 will be changed to No. 15)
16.	Do you feel motivated to learn Science after implementing Paper-Based Board Games? Why? 实施纸质版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？	Do you like to communicate with other group members while you are involved in using Paper-Based Board Games? Why? 在玩纸质版桌游的同时，你喜欢和其他组员交流吗？ 为什么？(No. 14 will be changed to No. 16)
17.	Are Paper-Based Board Games different from conventional teaching methods? Why? 纸质版桌游与传统教学方法有什么不同？ 为什么？	Do you like to use Paper-Based Board Games with friends in the next lesson? Why? 在下一堂课，你会期待和其他同学一起用纸质版桌游吗？ 为什么？ (No. 18 will be changed to No.17)
18.	Do you like to use Paper-Based Board Games in the next lesson? Why? 在下一堂课时，你会喜欢用纸质版桌游吗？ 为什么？	Do you like to use Paper-Based Board Games when you try to learn Science materials with classmates in the future? Why? 在往后的日子里，你会想和其他同学一块使用纸质版桌游来学习科学资料吗？ 为什么？ (No.19 will be changed to No. 18)
19.	Do you like to use Paper-Based Board Games when you try to learn Science materials in the future? Why? 在往后的日子里，你会喜欢用纸质版桌游来学习科学资料吗？ 为什么？	Would other teachers like to use Paper-Based Board Games to teach other subjects? Why? 你会希望其他老师使用纸质版桌游来教导其他科目吗？ 为什么？ (No.20 will be changed to No. 19)
20.	Would you like other teachers to use Paper-Based Board Games to teach other subjects? Why? 你会希望其他老师使用纸质版桌游来教导其他科目吗？ 为什么？	-

Table 4.12 shows the Revised Version of the interview protocol in implementing CBG after modification based on the comments given by two experienced Science teachers.

Table 4.12: Revised Version of the Interview Protocol in Implementing CBG after Discussion with Two Experienced Science Teachers

NO	VARIABLES / ITEMS	
	Adapted by Researcher	**After Discussion**
1.	Tell me about yourself. 介绍一下你自己。	Tell me about yourself. 介绍一下你自己。
2.	Do you know how to use electronic devices and learn knowledge? 你知道如何使用电子设备和学习知识吗?	Do you know how to use electronic devices and learn knowledge before? 在这之前，你知道如何使用电子设备和学习知识吗?
3.	Do you enjoy learning Science? Why? 你喜欢学习科学吗？ 为什么?	Do you enjoy learning Science before using computerized board games? 在还未使用电脑版桌游之前，你会喜欢学习科学吗?
4.	What do you think about computerized board games? 你对电脑版桌游有什么看法?	DELETED as it is similar with No. 5.
5.	Do you think computerized board games are new for you? Please give your opinion. 你认为电脑版桌游对你来说是新事物吗？ 请发表你的意见。	Do you think computerized board games are new for you? Please give your opinion. 你认为电脑版桌游对你来说是新事物吗？ 请发表你的意见。(No. 5 will be changed to No.4)
6.	Do you understand the content when you learn through computerized board games in the classroom? Why? 在课堂上时通过电脑版桌游学习的内容，你是否理解？ 为什么?	Do you better understand the content when you learn through computerized board games in the classroom than in the previous lesson? Why? 在课堂上时学习电脑版桌游的内容，和之前的教学活动相比，你是否更加理解呢？ 为什么？ (No. 6 will be changed to No.5)
7.	Do you like computerized board games to help you figure out what the Science materials are about? Why? 你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗？ 为什么?	Do you like computerized board games to help you figure out what the Science materials are about? Why? 你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗？ 为什么？ (No. 7 will be changed to No. 6)

Table 4.12 continued

8.	Do you learn a lot after using computerized board games in the classroom? Please give examples. 在课堂上玩电脑版桌游后，你会学到很多吗？ 请举例。	Do you learn a lot after using computerized board games in the classroom? Please give examples. 在课堂上玩电脑版桌游后，你会学到很多吗？ 请举例。(No. 8 will be changed to No. 7)
9.	Do you like using computerized board games to explain the contents or answer questions? Why? 你喜欢用电脑版桌游解释内容或回答问题吗？ 为什么？	Do you like using computerized board games to explain the contents or answer questions? Why? 你喜欢用电脑版桌游解释内容或回答问题吗？ 为什么？ (No. 9 will be changed to No. 8)
10.	Do you like to use computerized board games to list their Science materials? Why? 你喜欢用电脑版桌游列出其中的科学资料吗？ 为什么？	Do you like to use computerized board games to list their Science materials? Why? 你喜欢用电脑版桌游列出其中的科学资料吗？ 为什么？(No. 10 will be changed to No. 9)
11.	Do you like to work individually or collaboratively? Why? 你喜欢单独还是一起进行活动？ 为什么？	Do you feel motivated to learn Science after implementing computerized board games? Why? 实施电脑版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？(No. 16 will be changed to No. 11)
12.	Do you like to use computerized board games with your friends? Why? 你喜欢和朋友一起玩电脑版桌游吗？ 为什么？	Are computerized board games different from conventional teaching methods? Why? 电脑版桌游与传统教学方法有什么不同？ 为什么？(No. 17 will be changed to No. 12)
13.	Do you like to engage in a group activity to discuss Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？ 为什么？	How often do you learn Science knowledge by implementing educational technology like this? 你多久接触到这类的通信技术教学法来学习科学知识？ (No. 11 will be changed to No.13)
14.	Do you like to communicate with other group members while you are involved in using computerized board games? Why? 在玩电脑版桌游的同时，你喜欢和其他组员交流吗？ 为什么？	Do you like to use computerized board games with your friends? Why? 你喜欢和朋友一起玩电脑版桌游吗？ 为什么？ (No. 12 will be changed to No. 14)

Table 4.12 continued

15.	Do you relate the Science materials with the usage of computerized board games? Why? 你是否会将科学材料与电脑版桌游的运用联系起来吗？为什么？	Do you like to engage in a group activity to discuss Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？ 为什么？(No. 13 will be changed to No. 15)
16.	Do you feel motivated to learn Science after implementing computerized board games? Why? 实施电脑版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？	Do you like to communicate with other group members while you are involved in using computerized board games? Why? 在玩电脑版桌游的同时，你喜欢和其他组员交流吗？ 为什么？(No. 14 will be changed to No. 16)
17.	Are computerized board games different from conventional teaching methods? Why? 电脑版桌游与传统教学方法有什么不同？ 为什么？	Do you like to use computerized board games with friends in the next lesson? Why? 在下一堂课，你会期待和其他同学一起用电脑版桌游吗？ 为什么？ (No. 18 will be changed to No.17)
18.	Do you like to use computerized board games in the next lesson? Why? 在下一堂课时，你会喜欢用电脑版桌游吗？ 为什么？	Do you like to use computerized board games when you try to learn Science materials with classmates in the future? Why? 在往后的日子里，你会想和其他同学一块使用电脑版桌游来学习科学资料吗？为什么？(No.19 will be changed to No. 18)
19.	Do you like to use computerized board games when you try to learn Science materials in the future? Why? 在往后的日子里，你会喜欢用电脑版桌游来学习科学资料吗？ 为什么？	Would other teachers like to use computerized board games to teach other subjects? Why? 你会希望其他老师使用电脑版桌游来教导其他科目吗？ 为什么？(No.20 will be changed to No. 19)
20.	Would you like other teachers to use computerized board games to teach other subjects? Why? 你会希望其他老师使用电脑版桌游来教导其他科目吗？ 为什么？	-

An inter-rater reliability test was conducted for both interview protocols to ensure the interview protocol was reliable in this research. Table 4.13 presents the reliability test result, which involved testing 19 items. This interview protocol achieved a reliability score

of 0.776, indicating a good agreement between the two experienced Science teachers. However, the *p-value* being less than 0.05 suggests that the levels of agreement are significantly different from what would be expected by chance. This further supports the reliability of the interview protocol and strengthens the validity of the data obtained through interviews in this research.

Table 4.13: Results of Reliability Test toward Interview Protocol Instruments after Implementing PBBG and CBG

Variables	Number of Items	Number of Removed Items	Cronbach's Alpha	*p-value*
Interview Protocol	19	0	.776	.000
Original Total of Items				**19**
New Total of Items				**19**

4.7 Research Procedures

This research involved three groups of participants who willingly experienced three different teaching methods: CT, PBBG, and CBG at different times. The research procedures were conducted as follows:

1. The researcher issued an application letter to the Principal of Damai Tuition Centre, Sibu, seeking permission to conduct the research.
2. A consent letter outlining the terms and conditions for 10-year-old participants from various National-Type Chinese Primary Schools in Sibu was prepared upon obtaining permission.
3. One hundred sixty-six participants agreed to learn three Science topics through the CT involving PowerPoint presentations.

4. Additionally, 204 participants willingly participated in the PBBG, exposing them to the same Science topics as the CT.

5. Another 204 participants were informed and authorized to use electronic devices for CBG with CL, focusing on the same three Science topics.

6. Participants were assured that their personal information, such as their names and family backgrounds, would be stored securely and kept confidential.

7. Consent letters were issued to the parents of research participants as a hidden camera was used to record the feedback and responses during the implementation of PBBG and CBG, with CL in the Science classroom.

8. The pre-test was administered to all participants before the CT was conducted.

9. All participants completed the pre-test within a 2-hour timeframe.

10. The researcher analyzed the pre-test results before starting CT.

11. The researcher taught Year 4 three Science topics ('Properties of Light', 'Energy' and 'Material') to the participants during the school holidays.

12. After implementing CT, a post-test was conducted within 2 hours to evaluate the participants' learning outcomes.

13. The researcher marked and analyzed the post-test results.

14. A questionnaire was prepared following the implementation of CT to gather participants' feedback.

15. A pre-test was then administered to the participants in the PBBG group before introducing the board game.

16. Participants completed the pre-test within a 2-hour timeframe.

17. PBBG was implemented for one hour over three weeks, covering the three Science topics as CT method.

18. After implementing PBBG, a post-test was conducted within 2 hours to assess the participants' learning outcomes.

19. The researcher analyzed the post-test results.

20. A questionnaire was prepared following the implementation of PBBG to gather participants' feedback.

21. Subsequently, participants in the CBG group took a pre-test to evaluate the effectiveness of using CL in the Science classroom.

22. The pre-test was completed within 2 hours.

23. The researcher analyzed the pre-test results.

24. CBG was then employed to teach three Year 4 Science topics ('Properties of Light', 'Energy' and 'Material') in the classroom for three weeks.

25. During the implementation of CBG, the researcher noted the participants' learning activities.

26. A hidden camera was set up in the Science classroom to record the participants' activities, ensuring their consent and privacy.

27. The researcher acted as a participant observer to observe the learning process, while another teacher acted as a non-participant observer in the classroom.

28. After implementing CBG, participants were required to complete a post-test within 2 hours.

29. The researcher analyzed the post-test results.

30. A questionnaire was prepared following the implementation of CBG to gather participants' feedback.

31. Participants from CT, PBBG and CBG groups completed the questionnaire, providing their thoughts and opinions for learning activities.

32. The researcher reviewed how those 10-year-old participants engaged with and understood the selected Science topics and observed their communication during questioning, answering questions and collaborative activities in the classroom.

33. The researcher analyzed how the 10-year-old participants responded to the questionnaire regarding their involvement in CT, PBBG and CBG, with CL.

34. The researcher conducted post-task walkthroughs to enhance the consistency and effectiveness of classroom observations, especially since video recording was used in the Science classroom.

35. The researcher reviewed and recalled the responses or actions exhibited by specific participants while implementing PBBG and CBG in the classroom.

36. When identifying special responses or actions, the researcher asked the participants to provide explanations based on their actions the following day.

37. The researcher documented all the information and analyzed it later.

38. Furthermore, the researcher asked additional questions to validate the findings.

39. The observation notes were coded and analyzed.

40. The researcher conducted a semi-structured interview with CL after implementing PBBG and CBG.

41. The interviews were recorded, transcribed and thoroughly examined by the researcher.

42. All audio recordings of the interviews were directly saved on the computer.

43. After conducting post-task walkthroughs and reviewing video recordings of participants who exhibited special responses or actions, they were invited to attend interviews to provide additional information for analysis.

44. Finally, the researcher analyzed all the gathered information, including questionnaire responses, observation notes and interview data.

4.8 Data Analysis

This research analyzed the data using descriptive and inferential statistics. This analysis aimed to interpret the data and draw conclusions regarding the gender differences, the effectiveness of implementing CT, PBBG and CBG with CL and academic performance, learning motivation and social interaction of 10-year-old participants in the Science classroom.

4.8.1 Gender Differences

The research investigated gender differences among participants in the main study (CT, PBBG, and CBG). Normality tests were conducted for change scores from pre-test to post-test, mean scores of social interaction, and learning motivation, specifically for male and female genders. The result shows a substantial departure from normality, as the Mann-Whitney U test was used to identify significant gender differences towards change scores from pre-test to post-test, mean scores of social interaction, and learning motivation within the CT, PBBG, and CBG groups. The findings reveal that gender factor does not significantly impact the change scores from pre-test to post-test, mean scores of social interaction, and learning motivation scores achieved through the use of CT, PBBG and CBG in this research.

4.8.2 Pre-test and Post-test

In the context of the main study (CT, PBBG, and CBG), the researcher selected three topics from the Year 4 Science syllabus. The subsequent step was determined after performing individual normality tests on the pre-test and post-test scores. Normality tests were carried out to assess the distribution of change scores from pre-test to post-test. The outcomes of these tests indicated a significant deviation from the normal distribution within CT, PBBG and CBG groups. Kruskal-Wallis test was used, as the findings show a significant difference in the change scores among the CT, PBBG, and CBG groups for the given science topics. The Duncan Test has been conducted, as the results indicate that the CT group differs significantly from the CBG group, and the PBBG group differs

significantly from the CBG group. However, there is no statistically significant difference between the CT and PBBG groups.

4.8.3 Questionnaire

Questionnaires collected in this research were carefully reviewed to ensure each respondent responded to the study's instructions and requirements. The questions were clear, concise, and engaging, using language and formats suitable for children. Also, the questionnaires included closed-ended questions (e.g., rating scales) to allow 10-year-old participants to express their thoughts freely. Feedback obtained from questionnaires provided quantitative data regarding participants' preferences, experiences, and perceived effectiveness of PBBG and CBG. Hence, a descriptive and inferential statistical approach analyzed the data, particularly social interaction and learning motivation among the 10-year-old participants from National-Type Chinese Primary Schools in Sibu.

In this research, normality tests were conducted separately on the mean scores of social interaction and learning motivation. The results show that the social interaction and learning motivation data in all three groups (CT, PBBG, and CBG) significantly deviates from a normal distribution. Kruskall-Wallis test was applied, signifying a statistically significant difference in the mean scores of social interaction and learning motivation between at least two groups. The results of Dunn's Post Hoc Test reveal statistically significant differences in mean learning motivation scores among all possible pairs of the three groups: CT, PBBG, and CBG.

4.8.4 Classroom Observation Protocol

A classroom observation protocol was utilized and recorded during the class observation to gain further insights into various classroom occurrences, including the learning motivation and social interactions among the participants and between the researcher and the participants. The researcher observed how participants engaged with the games, their level of enthusiasm, collaboration with peers, and any challenges encountered during gameplay. This method allowed for the observation of non-verbal cues, such as body language and facial expressions, which provided additional context to the participants' experiences in applying PBBG and CBG with CL during the science learning in the classroom.

Although the classroom observation protocol provided examples, it did not provide detailed information for data analysis purposes. In addition to the classroom observation protocol, video recordings of the classroom sessions and feedback from non-participant observers were used. The resources were used to summarize the observations and establish a connection to the predetermined standard or indicator. The researcher then analyzed the observed data, considering its impact on the participants' learning motivation and social interaction. This analysis was conducted after implementing PBBG and CBG, with CL in the Science classroom at different times, allowing for a comprehensive understanding of the research outcomes.

4.8.5 Interview Protocol

Interviews were conducted with individual participants to delve deeper into their experiences with PBBG and CBG. These semi-structured interviews provided a more

nuanced understanding of the participants' perspectives, allowing them to express themselves freely and in their own words toward the application of PBBG and CBG with CL during the science learning. Through open-ended questions and prompts, interviewers could explore specific aspects of the board games that have been related in the questionnaires. Additionally, interviews allowed for clarification of responses and probing into areas of interest or concern raised by participants.

Furthermore, the researcher diligently recorded the feedback provided by the participants during the interview. A suitable transcription method was carefully selected and employed for this research, specifically manual thematic analysis, to code the collected interview data to ensure accuracy and effectiveness. This approach involved transcribing the interview verbatim and systematically applying codes to capture the participants' thoughts related to the research questions (Rahmawati, 2022). A form of thematic analysis and coding was used in this research (Lochmiller, 2021), as it followed the thematic analysis protocol by Braun & Clark (2006). All the interviews were transcribed right after the interview was completely conducted. It was a preliminary form of data analysis so that the researcher could reflect on the issues (Syamsuddin, 2022). Hence, this research decided to refer to six steps of Braun and Clark's (2006) thematic analysis protocol: (1) familiarization with the data, (2) generating initial codes, (3) generating themes, (4) reviewing potential themes, (5) defining and naming theme, and (6) producing the report.

4.9 Summary

This chapter offered comprehensive information on the research methodology, instruments and statistical analysis employed in this research. It began with a detailed

discussion of research design, encompassing various teaching approaches. Specifically, it highlighted the application of CT, PBBG and CBG methods among three distinct groups of 10-year-old participants. The next chapter focused on the pilot study, particularly the research hypotheses, procedures, data analysis, and results and findings.

CHAPTER 5

PILOT STUDY

5.1 Introduction

A pilot study served as the first step in the overall research process, acting as a smaller-scale investigation that assisted in the planning and modifying of the research approach (Floress et al., 2021). Typically, a pilot study involves pre-testing or trialling a research instrument with a sample size of 10-20% of the intended participants, thus ensuring a reasonable number of participants involved in the pilot study. Consequently, any irrelevant or unanswered questions or items can be identified and removed, finalising the questionnaire version (von Hippel & Cann, 2021).

In this pilot study, 24 participants were willingly assigned to the PBBG group, while another 24 were assigned to the CBG group. Their opinions and achievements were carefully analyzed. Questionnaires were also conducted with 24 research participants from each group. This approach aimed to avoid bias or controversy by not exclusively selecting 10-year-old participants as representatives in the pilot study. Furthermore, the classroom observation protocol underwent a pilot test for data collection. Finally, once research instruments were collected, the researcher analyzed them using Degang's (2010) criteria to assess their mean score interpretation (social interaction and learning motivation).

5.2 Research Hypotheses

The PBBG and CBG groups were selected for the pilot study, focusing on pre-test and post-test data, social interaction, and learning motivation. As a result, null hypotheses (Ho) and alternative hypotheses (Ha) were tested for each group.

H_{o1}: There is no significant difference in gender factors between PBBG and CBG groups.

H_{a1}: There is a significant difference in gender factors between PBBG and CBG groups.

H_{o2}: There is no significant difference in the change scores (pre-test to post-test) between PBBG and CBG groups.

H_{a2}: There is a significant difference in the change scores (pre-test to post-test) between PBBG and CBG groups.

H_{o3}: There is no significant difference in the mean scores (social interaction) between PBBG and CBG groups.

H_{a3}: There is a significant difference in the mean scores (social interaction) between PBBG and CBG groups.

H_{o4}: There is no significant difference in the mean scores (self-challenge dimension of learning motivation) between PBBG and CBG groups.

H_{a4}: There is a significant difference in the mean scores (self-challenge dimension of learning motivation) between PBBG and CBG groups.

H_{o5}: There is no significant difference in the mean scores (self-confidence dimension of learning motivation) between PBBG and CBG groups.

H_{a5}: There is a significant difference in the mean scores (self-confidence dimension of learning motivation) between PBBG and CBG groups.

H_{o6}: There is no significant difference in the mean scores (assessment dimension of learning motivation) between PBBG and CBG groups.

H_{a6}: There is a significant difference in the mean scores (assessment dimension of learning motivation) between PBBG and CBG groups.

H_{o7}: There is no significant difference in the mean scores (learning motivation dimension) between PBBG and CBG groups.

H_{a7}: There is a significant difference in the mean scores (learning motivation dimension) between PBBG and CBG groups.

H_{o8}: There is no significant difference in the mean scores (learning motivation) between PBBG and CBG groups.

H_{a8}: There is a significant difference in the mean scores (learning motivation) between PBBG and CBG groups.

5.3 Research Procedures

This pilot study focused on two groups voluntarily engaging with PBBG and CBG, with CL during separate sessions. The research procedures are as follows:

1. The researcher initiated the pilot study by submitting an application letter to the Principal of Damai Tuition Centre, Sibu, seeking permission.
2. A consent letter outlining the terms and conditions for 10-year-old participants from various National-Type Chinese Primary Schools in Sibu was prepared upon obtaining permission.

3. A total of 24 participants agreed to learn a specific subtopic from the Year 4 Science syllabus through implementing PBBG.
4. An additional 24 participants were informed and authorized to use electronic devices for CBG with CL, focusing on the same subtopic as the PBBG group.
5. Participants were assured that their personal information, including names and family backgrounds, would be securely stored and kept confidential.
6. Consent letters were provided to the parents of the research participants, as a hidden camera was employed to record feedback and responses during the implementation of PBBG and CBG with CL in the Science classroom.
7. A pre-test was administered to all participants before the commencement of PBBG.
8. All participants completed the pre-test within a 1-hour timeframe.
9. The researcher analyzed the pre-test results before commencing the PBBG sessions.
10. The subtopic "5.1 Light Travels in a Straight Line" was taught to the participants during the school holidays.
11. Following the implementation of PBBG, a post-test was conducted within 1 hour to evaluate the participants' learning outcomes.
12. The researcher proceeded to mark and analyze the post-test results.
13. A questionnaire was prepared to gather participant feedback after completing the PBBG sessions.
14. Subsequently, participants in the CBG group underwent a pre-test to evaluate the effectiveness of using CL in the Science classroom.
15. The pre-test was completed within 1 hour.
16. The researcher analyzed the pre-test results.

17. CBG was then employed to teach the same subtopic, "5.1 Light Travels in a Straight Line," in the classroom.
18. During the CBG implementation, the researcher observed the participants' learning activities.
19. A hidden camera was discreetly set up in the Science classroom to record the participants' activities, ensuring their consent and privacy.
20. The researcher, acting as a participant observer, observed the learning process.
21. After implementing CBG, participants were required to complete a post-test within 1 hour.
22. The researcher proceeded to analyze the post-test results.
23. A questionnaire was prepared to gather feedback from PBBG and CBG groups, collecting their thoughts and opinions on the learning activities.
24. PBBG and CBG group participants diligently completed the questionnaire, sharing their valuable insights and opinions regarding the learning activities.
25. The researcher reviewed how the 10-year-old participants engaged with and understood the selected Science topics, observing their communication during questioning, answering questions, and collaborative activities in the classroom.
26. An analysis was conducted to understand how the participants responded to the questionnaire regarding their involvement in PBBG and CBG with CL.
27. Post-task walkthroughs were carried out to enhance the consistency and effectiveness of classroom observations, especially considering the use of video recordings in the Science classroom.
28. The researcher reviewed and recalled the responses or actions exhibited by specific participants while implementing PBBG and CBG in the classroom.

29. Upon identifying special responses or actions, the researcher invited the participants to provide explanations based on their actions the following day.
30. All information was documented and later subjected to analysis.
31. Additional questions were posed to validate the findings.
32. Observation notes were coded and analyzed.
33. After implementing PBBG and CBG with CL, the researcher conducted semi-structured interviews.
34. The interviews were recorded, transcribed, and thoroughly examined by the researcher.
35. Audio recordings of the interviews were directly saved on the computer.
36. Following post-task walkthroughs and a review of video recordings of participants who exhibited special responses or actions, they were invited for interviews to provide additional information for analysis.
37. The researcher analysed all gathered information, including questionnaire responses, observation notes, and interview data.

5.4 Data Analysis

In this pilot study, an extensive data analysis was conducted using descriptive and inferential statistical techniques. The primary objective of this analytical process was to offer a comprehensive understanding of the collected data, enabling the derivation of conclusions regarding the treatment's effectiveness. Moreover, the analysis aimed to explore the associations between the utilization of PBBG and CBG, with CL, towards academic performance, learning motivation, and social interaction among 10-year-old participants in the Science classroom.

The scale standard for mean value was based on Degang's (2010) criteria, as shown in Table 5.1:

Table 5.1: Standard for Mean Value

Mean Value	Interpretation
1.00 – 1.79	Very low
1.80 – 2.59	Low
2.60 – 3.39	Moderate
3.40 – 4.19	High
4.20 – 5.00	Very high

Source: Degang (2010)

5.4.1 Assessment of Normality

To assess the normality of the gender data, change scores from pre-test to post-test, and mean scores of social interaction and learning motivation, the researcher applied the Kolmogorov-Smirnov and Shapiro-Wilk normality tests to determine if those data significantly deviated from a normal distribution. A *p-value* exceeding the selected alpha level (e.g., 0.05) would indicate that those data followed a normal distribution, while a *p-value* below the alpha level would suggest significant deviations from normality. Visual methods, such as histograms, were also employed to assess normality. A pattern closely following the diagonal line in the Q-Q plot would indicate that the gender data conformed to a normal distribution.

5.4.1.1 Gender Differences

In the pilot study (PBBG and CBG), normality tests were carried out separately for gender data.

Normality tests were conducted for change scores from pre-test to post-test, mean scores of social interaction, and learning motivation, specifically for male and female genders. The result shows a substantial departure from normality, as the Mann-Whitney U test was used to identify significant gender differences towards change scores from pre-test to post-test, mean scores of social interaction, and learning motivation within the PBBG and CBG groups. The findings reveal that the gender factor does not significantly impact the change scores from pre-test to post-test, mean scores of social interaction, and learning motivation scores achieved using PBBG and CBG in this pilot study.

5.4.1.2 Pre-test and Post-test

For the pilot study (PBBG and CBG), only the subtopic "5.1 Light Travels in a Straight Line" was selected, as the normality tests were conducted on the pre-test and then separately on the post-test scores. The results indicate a significant deviation from the normal distribution within PBBG and CBG groups. Mann-Whitney Test was used, as the findings show a significant difference in the change scores among the PBBG and CBG groups. The Independent Samples Mann-Whitney U Test has been conducted, as the results indicate that the change in test scores (from pre-test to post-test) for the PBBG group is significantly different from that of the CBG group for the specified subtopic.

5.4.1.3 Questionnaire

Normality tests were conducted separately on social interaction and learning motivation for the pilot study (PBBG and CBG). The results show that the social interaction and learning motivation data in both groups significantly deviates from a

normal distribution. Mann-Whitney U test was applied, as different results were obtained. There is no strong evidence to conclude that the PBBG and CBG groups significantly differ in social interaction. In contrast, the findings signify a statistically significant difference in the mean learning motivation scores between PBBG and CBG groups. The Independent Samples Mann-Whitney U Post Hoc Test results reveal statistically significant differences in mean learning motivation scores among PBBG and CBG groups.

5.5 Results and Findings of Pilot Study

This section focused on the pilot study findings for the gender differences between the implementation of PBBG and CBG. Subsequently, analyses were conducted to compare significant differences in the change scores from the pre-test to the post-test and the mean scores of social interaction and learning motivation among the 10-year-old participants from National-Type Chinese Primary Schools in Sibu.

5.5.1 How do genders differ between PBBG and CBG in learning Science among 10-year-old participants?

This pilot study explored potential gender differences in learning science using paper-based board games (PBBG) and computerised board games (CBG) among Year 4 participants. Table 5.2 and presents the results of normality tests conducted on data concerning gender after implementing PBBG and CBG respectively. Both the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate the change scores for both male and female 10-year-old participants after implementing PBBG do not significantly deviate from a normal distribution.

Table 5.2: Tests of Normality for Change Scores after Implementing PBBG among 10-year-old participants

	Aspect	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Change Scores	Male	.209	12	.153	.918	12	.270
	Female	.203	12	.186	.924	12	.323

Based on Table 5.3, the obtained F-statistic is 2.198 with a p-value of 0.152, indicating that there is no significant difference in variances between the groups at the conventional significance level of 0.05. Therefore, the assumption of equal variances is met. The mean difference between the groups is 0.91667, indicating that, on average; there is a slight difference in change scores favouring one group over the other. Since both confidence intervals include zero, it suggests that the true difference in change scores between the groups may be zero, indicating no significant difference. In summary, based on the t-test results, there is no statistically significant difference in change scores between the groups of 10-year-old participants after implementing PBBG.

Table 5.3: Results of Independent Sample t-Test for Change Scores after Implementing PBBG among 10-year-old participants

		Levene's Test for Equity of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Change Scores	Equal variances assumed	2.198	.152	.718	22	.480	.91667	1.27599	-1.72958	3.56291
	Equal variances not assumed			.718	19.179	.481	.91667	1.27599	-1.75233	3.58566

Table 5.4 indicates that both the Kolmogorov-Smirnov and Shapiro-Wilk tests suggest that the change scores for both male and female 10-year-old participants, following the implementation of both PBBG and CBG, do not exhibit significant deviations from a normal distribution.

Table 5.4: Tests of Normality for Change Scores after Implementing CBG among 10-year-old participants

	Aspect	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Change Scores	Male	.184	12	.200	.919	12	.280
	Female	.225	12	.096	.945	12	.568

Referring to Table 5.5, the obtained F-statistic is 0.008 with a p-value of 0.928, indicating no significant difference in variances between the groups at the conventional significance level of 0.05. Therefore, the assumption of equal variances is met. The mean difference between the groups is -0.83333, indicating that, on average, there is a slight difference in change scores favouring one group over the other, although this difference is not statistically significant. Since both confidence intervals include zero, it suggests that the true difference in change scores between the groups may be zero, indicating no significant difference. Hence, based on the t-test results, there is no statistically significant difference in change scores between the groups of 10-year-old participants after implementing CBG.

Table 5.5: Results of Independent Sample t-Test for Change Scores after Implementing CBG among 10-year-old participants

		Levene's Test for Equity of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Change Scores	Equal variances assumed	.008	.928	-1.520	22	.143	-.83333	.54818	-1.97020	.30353
	Equal variances not assumed			-1.520	21.924	.143	-.83333	.54818	-1.97042	.30376

Based on Table 5.6, both the Kolmogorov-Smirnov and Shapiro-Wilk tests suggest that the mean scores for social interaction among both male and female 10-year-old participants after implementing PBBG significantly deviate from a normal distribution.

Table 5.6: Tests of Normality for Social Interaction Mean Scores after Implementing PBBG among 10-year-old participants

	Aspect	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Mean Scores (Social Interaction)	Male	.446	12	.000	.592	12	.000
	Female	.279	12	.011	.784	12	.006

Referring to Table 5.7, there is no significant difference between the groups in terms of Social Interaction Mean Scores after implementing PBBG, since p-value is greater than 0.05. Hence, based on the Mann-Whitney U test results, there is no statistically significant difference in Social Interaction Mean Scores between male and female 10-year-old participants after implementing PBBG.

Table 5.7: Results of Mann-Whitney U test for Social Interaction Mean Scores after Implementing PBBG among 10-year-old participants

Aspect	Gender	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean score	Male	12	12.08	145.00	67.000	.736
	Female	12	12.92	155.00		

However, based on both the Kolmogorov-Smirnov and Shapiro-Wilk tests in Table 7, the mean scores for social interaction among both male and female 10-year-old participants after implementing CBG do not significantly deviate from a normal distribution.

Table 5.8: Tests of Normality for Social Interaction Mean Scores after Implementing CBG among 10-year-old participants

	Aspect	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Mean Scores (Social Interaction)	Male	.167	12	.200	.947	12	.598
	Female	.284	12	.008	.970	12	.065

Based on Table 5.9, the obtained F-statistic is 1.786 with a p-value of 0.195, indicating no significant difference in variances between the groups at the conventional significance level of 0.05. Therefore, the assumption of equal variances is met. The mean difference between the groups is 0.02750, indicating that, on average, there is a very slight difference in Social Interaction Mean Scores favoring one group over the other, although this difference is not statistically significant. Since both confidence intervals include zero, it suggests that the true difference in Social Interaction Mean Scores between the groups may be zero, indicating no significant difference. Therefore, based on the t-test results, there is no statistically significant difference in Social Interaction Mean Scores between the groups of 10-year-old participants after implementing CBG.

Table 5.9: Results of Independent Sample t-Test for Social Interaction Mean Scores after Implementing CBG among 10-year-old participants

		Levene's Test for Equity of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Change Scores	Equal variances assumed	1.786	.195	.477	22	.638	.02750	.05764	-.09205	.14705
	Equal variances not assumed			.477	20.917	.638	.02750	.05764	-.09241	.14741

According to Table 5.10, the results from both the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that the Learning Motivation Mean Scores for both male and female 10-year-old participants after implementing PBBG do not follow a normal distribution.

Table 5.10: Tests of Normality for Learning Motivation Mean Scores after Implementing PBBG among 10-year-old participants

	Aspect	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Mean Scores (Learning Motivation)	Male	.201	12	.197	.873	12	.071
	Female	.302	12	.003	.901	12	.164

Based on Table 5.11, since the p-value is greater than 0.05, there is no significant difference in learning motivation mean scores between male and female 10-year-old participants after the implementation of PBBG.

Table 5.11: Results of Mann-Whitney U test for Learning Motivation Mean Scores after Implementing PBBG among 10-year-old participants

Aspect	Gender	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean score	Male	12	13.58	163.00	59.000	.437
	Female	12	11.42	137.00		

Based on both the Kolmogorov-Smirnov and Shapiro-Wilk tests in Table 5.12, the mean scores for learning motivation among both male and female 10-year-old participants after implementing CBG do not significantly deviate from a normal distribution.

Table 5.12: Tests of Normality for Learning Motivation Mean Scores after Implementing CBG among 10-year-old participants

	Aspect	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Mean Scores (Learning Motivation)	Male	.228	12	.084	.868	12	.062
	Female	.244	12	.047	.868	12	.061

Based on Table 5.13, a p-value greater than 0.05 was obtained, as it suggests that there is no significant differences between the groups in gaining learning motivation mean scores after implementing CBG. Hence, based on the Mann-Whitney U test results, there is no statistically significant difference in Learning Motivation Mean Scores between male and female 10-year-old participants after implementing CBG.

Table 5.13: Results of Mann-Whitney U test for Learning Motivation Mean Scores after Implementing CBG among 10-year-old participants

Aspect	Gender	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean score	Male	12	12.00	144.00	66.000	.724
	Female	12	13.00	156.00		

5.5.2 How do pre-test and post-test scores differ between PBBG and CBG in learning Science among 10-year-old participants?

A. Pretest and Post-test

The pilot study for implementing PBBG and CBG was carried out for four consecutive days, from 20th February to 23rd February 2023. A total of 24 participants (50%) aged 10 were involved in PBBG; while another group of 24 (50%) simultaneously participated in CBG. The selected subtopic in implementing PBBG and CBG was "5.1: Light Travels in a Straight Line".

Table 5.14 shows the results of normality tests for subtopic "5.1: Light Travels in a Straight Line" towards pre-test and post-test assessments after using PBBG and CBG in the classroom.

Table 5.14: Tests of Normality for Pre-Test and Post-Test after Implementing PBBG and CBG among the 10-year-old participants for the "Subtopic 5.1: Light Travels in a Straight Line ".

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PBBG (Pre-test)	.232	24	.002	.868	24	.005
PBBG (Posttest)	.146	24	.200	.904	24	.027
CBG (Pre-test)	.211	24	.007	.851	24	.002
CBG (Posttest)	.179	24	.045	.900	24	.022

Table 5.15 shows the results of a Wilcoxon Signed Ranks comparing how pre-test and post-test scores changed between the PBBG and CBG groups. The results indicate a significant score difference between the two groups (Sig. = .000). This suggests that the

intervention (either PBBG or CBG) had a different impact on learning outcomes for the subtopic "Light Travels in a Straight Line" between the PBBG and CBG groups.

Table 5.15: Results of Wilcoxon Signed Ranks test for subtopic "Light Travels in a Straight Line" towards pre-test and post-test scores between PBBG and CBG groups

Aspect	Groups	N	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
Change Scores (Pre-test and Post-test)	PBBG	24	12.98	298.50	.000
	CBG	24	12.50	300.00	.000

5.5.3 How does social interaction differ between PBBG and CBG in learning Science among 10-year-old participants?

A. Questionnaire

In addition to the assessment scores, this pilot study incorporated a questionnaire, classroom observation and interview to explore the social interaction in learning Science using PBBG and CBG among 10-year-old participants.

Table 5.16 provides insights into the number of respondents involved and their corresponding interpretations for mean scores based on social interaction using Degang (2010) for PBBG and CBG groups. Notably, all the participants exhibited a very high mean score interpretation for social interaction after learning Science with the assistance of PBBG and CBG, respectively, in the classroom.

Table 5.16: Mean Score Interpretation for Social Interaction in Learning Science using PBBG and CBG among 10-year-old participants

Aspect	Groups	Average Mean Score	SD	Interpretation
Social Interaction	PBBG	4.82	.333	Very high
	CBG	4.76	.396	Very high

The data distribution for social interaction scores in both PBBG and CBG groups was found to be non-normal based on normality tests (Table 5.17).

Table 5.17: Tests of Normality for Social Interaction after Implementing PBBG and CBG among the 10-year-old participants

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
PBBG	.366	24	.000	.770	24	.000
CBG	.214	24	.006	.907	24	.031

A Wilcoxon Signed Ranks test revealed that there is a statistically significant difference in the mean scores of social interactions between the PBBG and CBG groups (Table 5.18). These findings highlight the importance of considering the impact of different instructional methods on social interaction outcomes in educational settings.

Table 5.18: Results of Wilcoxon Signed Ranks test for the mean scores of social interactions between PBBG and CBG groups

Aspect	Groups	N	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
Mean Score (social interaction)	PBBG	24	12.50	300.00	.000
	CBG	24	12.50	300.00	.000

B. Classroom Observation

The pilot study incorporated classroom observation alongside the questionnaire as an additional research instrument to investigate the social interaction features among the 48 participants aged 10. Two distinct groups were observed for class observation: the PBBG group and the CBG group, engaging in the Science classroom simultaneously. The observation revealed that the participants understood the lesson's structure, focusing on the subtopic 5.1, "Light Travels in a Straight Line", while playing PBBG and CBG, respectively. Furthermore, during the observation, active interaction between the researcher and the participants was evident as they continuously communicated while applying both versions of board games. Furthermore, the participants actively interacted

with one another, ensuring a seamless continuation of gameplay while simultaneously learning Science topics.

Additionally, it was noteworthy that the researcher incorporated technology to demonstrate the instruction for applying PBBG, even though The PBBG group did not utilize laptops in the classroom. The co-observer reported that the lesson emphasized student-centered and material-centered learning approaches. This observation highlighted the balanced focus on the active involvement of students and the utilization of relevant instructional materials throughout the lesson.

C. Interview

Based on the interview protocol sections, it was observed that some participants in the pilot study had limited experience and knowledge in utilizing electronic devices, particularly in applying CBG in the Science classroom. They were expected to acquire the necessary skills through the selected Science topic in the Year 4 syllabus at National-Type Chinese Primary Schools. Before engaging with PBBG and CBG, many participants expressed a lack of enthusiasm for learning Science, considering these board games unfamiliar. However, during the interview session, it was apparent that most participants understood the content and could connect the Science materials with PBBG and CBG. Consequently, they felt motivated to learn Science after implementing these board games.

Regarding social interaction, most participants preferred collaborative work and group activities when discussing Science questions. They also wanted to engage with their friends in the classroom while applying PBBG and CBG. This indicated a positive inclination towards interactive and CL experiences within Science education.

5.5.4 How does learning motivation differ between PBBG and CBG in learning Science among 10-year-old participants?

A. Questionnaire

This pilot study emphasized the learning motivation of 10-year-old participants, which was influenced by implementing PBBG and CBG with CL in the Science classroom. The study incorporated various research instruments such as questionnaires, classroom observation and interviews to evaluate the participant's level of learning motivation, specifically focusing on Subtopic 5.1, "Light Travels in a Straight Line".

Table 5.19 presents the value and mean score interpretations of learning motivation obtained from the 10-year-old participants who engaged in learning Science through implementing PBBG and CBG using Degang (2010). The results indicate that all participants have achieved a very high mean score interpretation for learning motivation after engaging with PBBG (Mean=4.80, SD=.342) and CBG (Mean=4.76, SD=.367) as the tools for learning Science in the classroom.

Table 5.19: Mean Score Interpretation for Social Interaction in Learning Science using PBBG and CBG among 10-year-old participants

Aspect	Groups	Average Mean Score	SD	Interpretation
Learning Motivation	PBBG	4.80	.342	Very high
	CBG	4.76	.367	Very high

Based on normality tests, the data distribution for learning motivation scores in both PBBG and CBG groups was found to be non-normal (Table 5.20).

Table 5.20: Tests of Normality for Learning Motivation after Implementing PBBG and CBG among 10-year-old participants

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PBBG	.242	24	.001	.903	24	.024
CBG	.195	24	.019	.893	24	.015

Based on Table 5.21 the results of a Wilcoxon Signed Ranks test indicate a notable disparity in the mean scores of learning motivation between the PBBG and CBG groups. These findings underscore the necessity of assessing the influence of diverse instructional approaches on social interaction outcomes within educational environments.

Table 5.21: Results of Wilcoxon Signed Ranks test for the mean scores of learning motivation between PBBG and CBG groups

Aspect	Groups	N	Mean Rank	Sum of Ranks	Asymp. Sig. (2-tailed)
Mean Score (learning motivation)	PBBG	24	12.50	300.00	.000
	CBG	24	12.50	300.00	.000

B. Classroom Observation

Learning motivation was a key focus in a pilot study investigating social interaction features among the 48 participants aged 10. Classroom observations were conducted towards two distinct groups, namely the PBBG group and the CBG group, within the Science classroom. The findings indicated that the participants understood the lesson's structure, subtopic 5.1, "Light Travels in a Straight Line", while engaging with both versions of board games.

Furthermore, the observation indicated that the participants exhibited high motivation levels while playing PBBG and CBG, actively seeking to acquire knowledge with their group members. As a result, they continued to engage with PBBG and CBG,

collaborating with their peers and exploring the Science concepts without requiring any encouragement from the researcher during classroom activities. Additionally, the researcher strategically incorporated technology before implementing PBBG and CBG, facilitating easier comprehension of the rules and knowledge acquisition for the participants.

Importantly, the study observed the researcher's emphasis on employing student-centered and material-centered learning approaches, fostering an environment where participants were motivated to actively understand the skills and learning contents of the selected subtopic.

The study sheds light on the positive impact of PBBG and CBG in promoting social interaction and learning motivation among young learners. Integrating technology and adopting student-centered approaches further enhance the effectiveness of these board game-based learning methods in Science education.

C. Interview

According to the interview protocol, it became apparent that some participants had limited experience with electronic devices, as they had seldom been exposed to such technological tools before this pilot study. It was supported by the statements below: -

I think I have zero experience to use ehmm…electronic devices…. (CBG G3P1)

…use electronic devices to…ehmm…surf the Internet….so, I am not sure whether I can…use it to learn knowledge or not… (CBG G5P2)

As part of the study, they were required to acquire these skills to engage with CBG effectively. Despite these initial challenges, the findings revealed that most participants expressed a lack of motivation to learn Science, attributing it to their teachers' reliance on CT methods in the Science classroom.

Ehmm…those contents when I am… trying to apply this computerized board game, especially when it… compared with conventional teaching method before… (PBBG G1P4)

I was exposed to…Paper-Based Board Game, as it… hmm…compared to previous lessons…I think I can understand the… ah…content easily… (PBBG G2P2)

For me, I think I can understand the learning content better... when I am applying this board game in the classroom….hmm…if… compared with previous lessons… (CBG G3P1)

I can understand the Science content…ah-ha… when I learn them with the help of…these board games if really… want to compare with previous lesson… (CBG G2P4)

However, during the interview session, it was evident that the participants understood the learning content and were motivated to relate the Science materials with PBBG and CBG. They expressed a sense of motivation and engagement when provided with opportunities to work collaboratively and complete tasks within the allocated time while playing board games. This positive response indicated a positive inclination towards their Science learning experiences as they were intrinsically and extrinsically motivated.

5.5 Summary

This chapter was dedicated to a comprehensive data analysis of the gathered data, encompassing various aspects such as examining gender differences between PBBG and CBG, with CL, changes in scores from pretest to post-test, and the mean scores associated

with social interaction and learning motivation. The study employed pre-tests, post-tests, and questionnaires to assess the impact of PBBG and CBG, with CL, on the Science learning experiences of 10-year-old participants.

The analysis findings suggest that gender does not significantly influence the scores from pre-test to post-test, as well as the mean scores for social interaction and learning motivation among participants engaging with PBBG and CBG in this pilot study. However, significant differences emerged when comparing the groups using these teaching methods. Specifically, the PBBG group exhibited greater learning performance than the CBG group. This implies that PBBG was more effective in enhancing learning outcomes in the Science classroom than the other method (CBG). Additionally, this chapter provides a detailed insight into the research instruments, procedures, and data analysis techniques. The data collected adhered to the predefined research plan, and both quantitative and qualitative analysis methods were employed, as outlined in Chapter 6.

CHAPTER 6

RESULTS

6.1 Introductionn

This chapter presents the research's findings involving quantitative and qualitative methods. The collected data were analyzed using SPSS Version 23.0. The findings were compiled and analyzed, focusing on the demographic characteristics of the respondents and comparing three groups of 10-year-old participants: those using CT, PBBG, and CBG with CL. The comparison was conducted across three key aspects: (1) academic performance, (2) social interaction, and (3) learning motivation in the Science classroom.

The results are discussed based on these research questions:

1) What were the design features of PBBG and CBG specifically tailored for 10-year-old participants' Science learning?
2) How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
3) How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
4) How does social interaction differ between CT, PBBG and CBG in learning Science among 10-year-old participants?
5) How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

The findings from the analysis provided valuable insights into the effectiveness of the different teaching methods and their impact on academic performance, social interaction, and learning motivations among the 10-year-old participants in the Science classroom.

6.2 Respondents' Demographic Profiles

This research included 574 participants aged 10, divided into CT, PBBG, and CBG. There were 57 male participants (34.3%) and 109 female participants (65.7%) who willingly took part in learning Science through CT (PowerPoint Presentation). Table 6.1 provides a comprehensive distribution of the respondents exposed to CT (PowerPoint Presentation).

Table 6.1: CT Group

Genders	**Group 1 - CT**	
	Frequency	**Percentage (%)**
Male	57	34.3
Female	109	65.7
Total	**166**	**100**

Sixty-six male participants (32.4%) and 138 female participants (67.6%) were willingly engaged in learning and playing PBBG in the Science classroom. The distribution of 10-year-old participants within this group can be found in Table 6.2**.**

Table 6.2: PBBG Group

Genders	Group 2 - PBBG	
	Frequency	**Percentage (%)**
Male	66	32.4
Female	138	67.6
Total	**204**	**100**

The CBG group comprised 63 male participants (30.9%) and 141 female participants (69.1%). Table 6.3 presents the frequency and percentage distribution of 10-year-old participants involved in the group utilizing CBG in the Science classroom.

Table 6.3: CBG Group

Genders	Group 3 - CBG	
	Frequency	**Percentage (%)**
Male	63	30.9
Female	141	69.1
Total	**204**	**100**

6.3 Findings of the Research

This research focused on three main groups: CT, PBBG and CBG, with CL. However, the analysis of the first teaching method was limited to pre-test, post-test and questionnaires among the 10-year-old participants. In contrast, this research emphasizes the comprehensive exploration of the CT, PBBG and CBG, with quantitative and qualitative CL. Furthermore, this approach allowed for comparing mean scores and determining any significant difference between these two groups.

By employing various research instruments, the research aimed to delve deeper into applying CT, PBBG and CBG with CL, providing a more comprehensive understanding of

their impact. The quantitative and qualitative analysis helped capture different aspects of the participants' experiences and allowed for a thorough examination of the effectiveness of PBBG and CBG compared to CT. The research sought to identify any notable variation and assess these differences' significance by comparing change scores (pre-test and post-test) and mean scores (social interaction and learning motivation) between CT, PBBG and CBG groups.

6.3.1 How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

This research focused on understanding gender differences between CT, PBBG, and CBG based on academic performance, social interaction and learning motivation separately. Table 6.4 indicates the results of the Mann-Whitney U test toward change scores for the gender differences in the CT group.

Table 6.4: Results of Mann-Whitney U test toward change scores for the gender differences in the CT group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Change Score (CT)	Male	57	80.04	4562.00	2909.000	.500
	Female	109	85.31	9299.00		

Table 6.4 shows that 57 male and 109 female participants were involved in the CT group. For males, the sum of ranks is 4562.00, and for females, it is 9299.00. In this analysis, the average rank for males is 80.04, while for females, it is 85.31. For males, the sum of ranks is 4562.00, and for females, it is 9299.00. The U-Statistic is 2909.000, as its *p-value* is .500. The results indicate that the *p-value* associated with this test is 0.500. Since this p-value is greater than the typical significance level of 0.05, it suggests no statistically

significant difference in change scores between male and female participants in the CT group. In other words, there is no strong evidence to conclude that gender significantly impacts the change in scores achieved through CT in this research.

Table 6.5 indicates the results of the Mann-Whitney U test toward change scores for the gender differences in the PBBG group.

Table 6.5: Results of Mann-Whitney U test toward change scores for the gender differences in the PBBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Change Score (PBBG)	Male	66	101.11	6673.50	4462.500	.816
	Female	138	103.16	14236.50		

Referring to Table 6.5, 66 male and 138 female participants were involved in the PBBG group. In this analysis, the average rank for males is 101.11, while for females, it is 103.16. For males, the sum of ranks is 6673.50, and for females, it is 14236.50. In this case, the U-Statistic is 4462.500, followed by the *p-value* of 0.816. The findings reveal that the *p-value* obtained from this test is 0.816. As this *p-value* exceeds the conventional significance level of 0.05, it implies no statistically significant differences in change scores between male and female participants within the PBBG group. In simpler terms, there is insufficient evidence to conclude that gender plays a significant role in the changes in scores achieved through the utilization of PBBG in this research.

Table 6.6 indicates the results of the Mann-Whitney U test toward change scores for the gender differences in the CBG group.

Table 6.6: Results of Mann-Whitney U test toward change scores for the gender differences in the CBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Change Score (CBG)	Male	63	111.83	7045.00	3854.000	.131
	Female	141	98.33	13865.00		

Based on Table 6.6, 66 male and 138 female participants were involved in the CBG group. The average rank for males is 111.83, while for females, it is 98.33. For males, the sum of ranks is 7045.00, and for females, it is 13865.00. In this case, the U-Statistic is 3854.000, followed by the *p-value* of 0.131. The findings presented in Table 5.6 reveal that the *p-value*, as determined by the Mann-Whitney U test for change scores within the CBG group, is 0.131. Given that this *p-value* surpasses the standard significance threshold of 0.05, it can be inferred that there is no statistically significant distinction in change scores between male and female participants in the CBG group. In simpler words, the data does not provide enough evidence to support the notion that gender plays a significant role in the changes in scores resulting from the utilization of CBG in this research.

Table 6.7 indicates the results of the Mann-Whitney U test toward mean scores of social interaction for the gender differences in the PBBG group.

Table 6.7: Results of Mann-Whitney U test toward mean scores of social interaction for the gender differences in the PBBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean Score (Social Interaction)	Male	66	107.86	7119.00	4200.000	.346
	Female	138	99.93	13791.00		

The analysis of gender differences within the PBBG group, as shown in Table 6.7, reveals that the Mann-Whitney U test for mean social interaction scores yields a U-Statistic of 4200.000 with a two-tailed asymptotic significance of 0.346. With a *p-value* of 0.346,

greater than the typical significance level of 0.05, there is no statistically significant difference in mean social interaction scores between male and female participants in the PBBG group. In other words, this result suggests that gender does not significantly influence the social interaction scores achieved through using PBBG in this research.

Table 6.8 indicates the results of the Mann-Whitney U test toward mean scores of social interaction for the gender differences in the CBG group.

Table 6.8: Results of Mann-Whitney U test toward mean scores of social interaction for the gender differences in the CBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean Score (Social Interaction)	Male	63	106.13	6686.50	4212.500	.542
	Female	141	100.88	14223.50		

The analysis of gender differences within the CBG group, as indicated in Table 6.8, reveals the results of the Mann-Whitney U test for mean social interaction scores. The U-Statistic is 4212.500 with a two-tailed asymptotic significance of 0.542. A p-value of 0.542, which exceeds the conventional significance level of 0.05, indicates no statistically significant difference in mean social interaction scores between male and female participants in the CBG group. Overall, the gender factor does not appear to significantly impact the social interaction scores achieved using CBG in this research.

Table 6.9 indicates the results of the Mann-Whitney U test toward mean scores of learning motivation for the gender differences in the PBBG group.

Table 6.9: Results of Mann-Whitney U test toward mean scores of learning motivation for the gender differences in the PBBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean Score (Learning Motivation)	Male	66	96.28	6354.50	4143.500	.293
	Female	138	105.47	14555.50		

The analysis of gender differences within the PBBG group, as shown in Table 6.9, presents the results of the Mann-Whitney U test for mean learning motivation scores. The U-Statistic is 4143.500 with a two-tailed asymptotic significance of 0.293. A p-value of 0.293, higher than the conventional significance level of 0.05, suggests no statistically significant difference in mean learning motivation scores between male and female participants in the PBBG group. Hence, the gender factor does not significantly influence the learning motivation scores achieved using PBBG in this research.

Table 6.10 indicates the results of the Mann-Whitney U test toward mean learning motivation scores for the gender differences in the CBG group.

Table 6.10: Results of Mann-Whitney U test toward mean scores of learning motivation for the gender differences in the CBG group

Aspect	Groups	N	Mean Rank	Sum of Ranks	U-Statistic	Asymp. Sig. (2-tailed)
Mean Score (Learning Motivation)	Male	63	106.94	6737.00	4162.000	.470
	Female	141	100.52	14173.00		

The analysis of gender differences within the CBG group, as presented in Table 6.10, reveals the results of the Mann-Whitney U test for mean learning motivation scores. The U-Statistic is 4162.000, and the two-tailed asymptotic significance is 0.470. A p-value of 0.470, which exceeds the conventional significance level of 0.05, suggests no statistically significant difference in mean learning motivation scores between male and female participants in the CBG group. Therefore, the gender factor does not significantly impact the learning motivation scores achieved using CBG in this research.

The significant results indicating that both genders do not play a significant role in the changes in scores resulting from the utilization of CT, PBBG, and CBG, as well as their minimal impact on social interaction and learning motivation, are highly relevant to

the goal of the study investigation outlined in the problem statement. The findings suggest that while different teaching methods may have varying effects on academic performance, they do not show a significant difference in outcomes between genders. This underscores the broader issue identified in the problem statement regarding the decline in international rankings, emphasizing the need to explore innovative teaching methods that address the lack of emphasis on HOTs in science education.

Furthermore, the results indicate that traditional teaching methods, as well as PBBG and CBG, do not significantly impact social interaction and learning motivation among students of both genders. This aligns with the problem statement highlighting the challenges stemming from misconceptions, lack of understanding, and educational obstacles associated with traditional teaching methods. The findings imply that neither traditional teaching nor board game-based approaches significantly impact learning motivation. This supports the problem statement's assertion that low motivation among pupils can be a significant barrier to effective science learning. It suggests the need for interventions that can better engage and motivate students in the learning process and strategies.

Next, the findings imply that neither traditional teaching nor board game-based approaches significantly impact learning motivation. This supports the problem statement's assertion that low motivation among pupils can be a significant barrier to effective science learning. It suggests the need for interventions that can better engage and motivate students in the learning process. The research demonstrates that while PBBG and CBG have the potential to address shortcomings in traditional teaching and digital games, their current implementation does not significantly impact social interaction or learning motivation.

This highlights the gap between the potential of innovative teaching methods and their actual utilization in addressing.

The findings affirm the relevance and appropriateness of the problem statements outlined in the research objectives. They demonstrate how the lack of significant impact from different teaching methods on social interaction, learning motivation, and academic performance aligns with the identified issues in science education. In summary, the significant results regarding the non-significant role of gender and the limited impact on social interaction and learning motivation provide valuable insights into the effectiveness of different teaching methods in addressing the identified challenges in science education, as outlined in the problem statements. They emphasize the need for further exploration and refinement of instructional strategies to improve science learning outcomes among primary school students.

6.3.2 How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

Pre-test and Post-test

This research incorporated pre-test and post-test assessments after implementing CT (PowerPoint Presentations) in Science classrooms. It also implemented pre-test and post-test assessments for three selected Science topics after applying PBBG and CBG, with CL among the 10-year-old participants. Table 6.11 shows the results for normality tests after using CT, PBBG and CBG to teach "Properties of Light" in the classroom.

Table 6.11: Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Properties of Light"

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CT (Pre-test)	.291	166	.000	.784	166	.000
CT (Post-test)	.271	166	.000	.812	166	.000
PBBG (Pre-test)	.274	204	.000	.797	204	.000
PBBG (Post-test)	.171	204	.000	.893	204	.000
CBG (Pre-test)	.320	204	.000	.781	204	.000
CBG (Post-test)	.247	204	.000	.844	204	.000

Referring to Table 6.11, the results provide information on the normality tests conducted for pre-test and post-test data after implementing CT, PBBG, and CBG among 10-year-old participants, specifically focusing on the topic "Properties of Light." In all cases, whether CT, PBBG, or CBG, the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate statistically significant departures from a normal distribution. The *p-values* for all tests are extremely small, approaching zero ($p < 0.001$). This suggests that the data for pre-tests and post-tests for each teaching method deviates significantly from a normal distribution.

In summary, this research's normality tests for pre-test and post-test data show that the data does not follow a normal distribution pattern. Therefore, non-parametric tests were considered for the subsequent data analysis, as the assumption of normality required for parametric tests is unmet.

Table 6.12 shows the results of normality tests after using CT, PBBG and CBG to teach "Energy" in the classroom.

Table 6.12: Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Energy"

Groups	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
CT (Pre-test)	.277	166	.000	.789	166	.000
CT (Post-test)	.246	166	.000	.861	166	.000
PBBG (Pre-test)	.303	204	.000	.754	204	.000
PBBG (Post-test)	.173	204	.000	.913	204	.000
CBG (Pre-test)	.330	204	.000	.755	204	.000
CBG (Post-test)	.176	204	.000	.883	204	.000

Table 6.12 presents the results of normality tests conducted for pre-test and post-test data after implementing CT, PBBG, and CBG among 10-year-old participants, focusing on "Energy." In all cases, whether CT, PBBG, or CBG, the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate statistically significant departures from a normal distribution. The *p-values* for all tests are extremely small ($p < 0.001$), signifying that the pre-test and post-test data deviate significantly from a normal distribution.

To summarize, this research's normality tests for pre-test and post-test data reveal that the data does not adhere to a normal distribution pattern. Hence, non-parametric tests were considered for subsequent data analysis, as the assumption of normality required for parametric tests is not satisfied.

Table 6.13 shows the results for normality tests after using CT, PBBG and CBG to teach "Materials" in the classroom.

Table 6.13: Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for the Topic "Materials"

Groups	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
CT (Pre-test)	.279	166	.000	.773	166	.000
CT (Post-test)	.259	166	.000	.803	166	.000
PBBG (Pre-test)	.304	204	.000	.744	204	.000
PBBG (Post-test)	.279	204	.000	.821	204	.000
CBG (Pre-test)	.254	204	.000	.649	204	.000
CBG (Post-test)	.115	204	.000	.894	204	.000

Table 6.13 provides the results of normality tests performed on pre-test and post-test data after implementing CT, PBBG, and CBG among 10-year-old participants, focusing on "Materials." For all the groups, including CT, PBBG, and CBG, both the Kolmogorov-Smirnov and Shapiro-Wilk tests reveal significant departures from a normal distribution. The p-values are extremely small ($p < 0.001$) for all cases, indicating that the pre-test and post-test data significantly deviate from a normal distribution.

In summary, the results of the normality tests for pre-test and post-test data related to the topic "Materials" indicate a clear deviation from normality. Therefore, non-parametric tests were recommended for further analysis since the assumption of normality required for parametric tests was not met.

Table 6.14 shows the results of normality tests after using CT, PBBG and CBG to teach those three Science topics in the classroom.

Table 6.14: Tests of Normality for Pre-Test and Post-test after Implementing CT, PBBG and CBG among the 10-year-old participants for Three Science Topics

Groups	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
CT (Pre-test)	.304	166	.000	.757	166	.000
CT (Post-test)	.275	166	.000	.804	166	.000
PBBG (Pre-test)	.322	204	.000	.740	204	.000
PBBG (Post-test)	.249	204	.000	.855	204	.000
CBG (Pre-test)	.322	204	.000	.714	204	.000
CBG (Post-test)	.202	204	.000	.867	204	.000

Table 6.14 presents the results of normality tests conducted on pre-test and post-test data after implementing CT, PBBG, and CBG among 10-year-old participants for three different science topics. For each group, the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that both pre-test and post-test data significantly depart from a normal distribution. The *p-values* for all these tests are extremely small ($p < 0.001$), signaling a substantial deviation from the normality assumption.

Overall, the results of the normality tests for pre-test and post-test data related to the three science topics reveal a significant departure from normality across all groups. Therefore, the data does not adhere to a normal distribution, and it is advisable to employ non-parametric tests for further analysis due to violating the normality assumption required for parametric tests.

Table 6.15 indicates the results of the Kruskall-Wallis test for change scores from pre-test to post-test between CT, PBBG and CBG groups.

Table 6.15: Results of Kruskall-Wallis test for change scores from pre-test to posttest between CT, PBBG and CBG groups

Groups	**N**	**Mean Rank**	**df**	$\mathbf{x^2}$	***p***
CT	166	133.23	2	220.075	.000
PBBG	204	384.81			
CBG	204	315.73			

Table 6.15 displays the results of a Kruskal-Wallis test conducted to compare the change scores from pre-test to post-test among three groups: CT, PBBG, and CBG. For the CT group (n = 166), the mean rank of the change scores is 133.23. For the PBBG group (n = 204), the mean rank of the change scores is 384.81. For the CBG group (n = 204), the mean rank of the change scores is 315.73. The Kruskal-Wallis test resulted in a chi-square statistic (x^2) of 220.075 with 2 degrees of freedom and a *p-value* of 0.000. This indicates a statistically significant difference among the three groups regarding the pre-test to post-test change scores.

The Kruskal-Wallis test suggests a significant difference in the change scores among the CT, PBBG, and CBG groups for the given science topic. The *p-value* is extremely small ($p < 0.001$), indicating strong evidence against the null hypothesis that no difference exists. Further post hoc test (Dunn's Test) was applied to determine which specific group differences drive this overall significance.

Table 6.16 shows the results of Kruskal-Wallis Dunn's Post Hoc Test for change scores between CT, PBBG and CBG groups.

Table 6.16: Kruskal-Wallis Dunn's Post Hoc Test results for change scores between CT, PBBG and CBG groups.

Post Hoc Test	**Chi-Square**	**Asymp. Sig. (2-tailed)**
CT vs. PBBG	201.936	.083
CT vs. CBG	135.414	.000
PBBG vs. CBG	21.012	.000

Table 6.16 presents the results of the Kruskal-Wallis Dunn's Post Hoc Test, which was conducted to examine further the specific differences in change scores between the CT, PBBG, and CBG groups.

To compare CT and PBBG groups, the chi-square statistic for this comparison is 201.936. The associated *p-value* is 0.083. The chi-square statistic of 201.936 indicates a significant difference between the CT and PBBG groups regarding change scores. The *p-value* of 0.083 suggests this difference is not statistically significant at the conventional alpha level of 0.05. While there is a numerical difference, it does not meet the criteria for statistical significance.

For the comparison between CT and CBG groups, the chi-square statistic for this comparison is 135.414, as the associated *p-value* is 0.000 (two-tailed). The chi-square statistic of 135.414 indicates a significant difference between the CT and CBG groups regarding change scores. The *p-value* of 0.000 is less than the alpha level (0.05), demonstrating that the difference between the CT and CBG groups is statistically significant.

To compare PBBG and CBG groups, the chi-square statistic for this comparison is 21.012. Its associated p-value is 0.000 (two-tailed). The chi-square statistic 21.012 indicates a significant difference between the PBBG and CBG groups regarding change

scores. The *p-value* of 0.000 is less than the alpha level (0.05), indicating that the difference between the PBBG and CBG groups is statistically significant.

In summary, Kruskal-Wallis Dunn's Post Hoc Test reveals significant differences in change scores between the CT, PBBG, and CBG groups. Specifically, the CT group differs significantly from the CBG group, and the PBBG group differs significantly from the CBG group. However, there is no statistically significant difference between the CT and PBBG groups at the 0.05 significance level.

The most significant result indicates that PBBG, when combined with CL, were the most effective in helping 10-year-old participants master knowledge and skills from selected science topics directly. The finding highlights the impact of teaching methods on academic performance, with PBBG and CL proving to be the most effective. This directly relates to the problem of declining international rankings, suggesting that innovative teaching approaches like PBBG with CL can potentially reverse this trend by enhancing students' mastery of science topics. The effectiveness of PBBG with CL in facilitating science learning directly addresses the issue of low scores attributed to a lack of understanding and misconceptions stemming from traditional teaching methods. By providing a more engaging and interactive learning experience, PBBG with CL helps students overcome these challenges and master science concepts more effectively.

The superior effectiveness of PBBG with CL compared to traditional teaching methods, such as PowerPoint presentations, suggests that innovative approaches can help address low motivation among students. The engaging and interactive nature of PBBG with CL may increase student interest and motivation in science learning, thereby overcoming this significant barrier to effective learning. The finding that PBBG with CL is the most effective teaching method underscores the potential of these innovative

approaches to address the scarcity of interactive learning resources tailored for science education in Chinese primary schools. By demonstrating the effectiveness of PBBG with CL in enhancing academic performance, the study highlights the importance of incorporating such resources into science education curricula.

The result underscores the potential of PBBG and CBG to address the shortcomings of traditional teaching methods by providing hands-on, interactive, and collaborative learning experiences. Specifically, the effectiveness of PBBG with CL in facilitating science learning demonstrates how these approaches can improve student outcomes and contribute to the overall improvement of science education. The findings validate the relevance of the problem statements by demonstrating how innovative teaching approaches like PBBG with CL can effectively address the identified challenges in science education. By directly impacting participants' academic performance, the study provides evidence supporting the importance of addressing these challenges through innovative pedagogical methods.

6.3.3 How does social interaction differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

A. Questionnaire

The data collected from 166 participants, aged 10, who were exposed to the CT (PowerPoint Presentation) were used to assess social interactions in the classroom. Furthermore, the questionnaire administered in this research included items on the social interaction aspect of 204 participants, aged 10, during their Science learning through implementing PBBG and CBG, respectively. Based on the interpretation of the mean score

provided by Degang (2010), **Table 6.17** presents insights into the number of respondents involved and their corresponding interpretations for mean scores using Degang (2010) for CT, PBBG and CBG groups based on social interaction. The findings revealed that all participants demonstrated moderate social interaction in the Science classroom. However, most of the participants perceived that they seldom interacted with each other during Science learning sessions. This suggests that the CT, as represented by the PowerPoint Presentation, may have limitations in fostering active social interactions among 10-year-old learners in Science education. Notably, all the participants exhibited a very high mean score interpretation for social interaction after learning Science with the assistance of PBBG and CBG, respectively, in the classroom.

Table 6.17: Mean Score Interpretation for Social Interaction in Learning Science using CT, PBBG and CBG among 10-year-old participants

Aspect	Groups	Average Mean Score	SD	Interpretation
Social Interaction	CT	2.81	.684	Moderate
	PBBG	4.87	.346	Very high
	CBG	4.80	.397	Very high

According to Table 6.17, a comparison of the average mean scores and standard deviation for the CT group (Mean=2.81, SD=0.684), PBBG group (Mean=4.87, SD=0.346) and CBG group (Mean=4.80, SD=0.397), reveals different interpretation. The social interaction in the CT group is categorized as "Moderate." This means that the level of social interaction in the CT group, on average, is in the moderate range, indicating a moderate degree of social interaction among participants. For the PBBG group, it is characterized as "Very high." This suggests that, on average, the PBBG group exhibits a very high level of social interaction among participants, indicating strong social interactions. Then, the social interaction in the CBG group is also classified as "Very

high." On average, the CBG group demonstrates a very high level of social interaction among participants, similar to the PBBG group.

Overall, based on the average mean scores and their associated interpretations, it is evident that the PBBG and CBG groups both have a very high level of social interaction among the 10-year-old participants. In contrast, the CT group shows a moderate level of social interaction, notably lower than that of the PBBG and CBG groups.

Table 6.18 shows the results of normality tests for social interaction after using CT, PBBG and CBG among the 10-year-old participants in the classroom.

Table 6.18: Tests of Normality for Social Interaction after Implementing CT, PBBG and CBG among the 10-year-old participants

Groups	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
CT	.222	166	.000	.836	166	.000
PBBG	.233	204	.000	.868	204	.000
CBG	.191	204	.000	.915	204	.000

Table 6.18 presents the results of normality tests for social interaction after implementing CT, PBBG, and CBG among 10-year-old participants.

For CT Group, its Kolmogorov-Smirnov Statistic is 0.222, while the Shapiro-Wilk Statistic is 0.836 with a significance level 0.000 ($p < 0.001$). Hence, the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that the data significantly deviates from a normal distribution ($p < 0.001$). In other words, the data for social interaction in the CT group is not normally distributed.

In the PBBG group, the Kolmogorov-Smirnov Statistic is 0.233, and the Shapiro-Wilk Statistic is 0.868, with a significance level of 0.000 ($p < 0.001$). Like the CT group,

the PBBG group's data significantly departs from a normal distribution ($p < 0.001$), as indicated by the Kolmogorov-Smirnov and Shapiro-Wilk tests.

In the CBG group, the Kolmogorov-Smirnov Statistic registers as 0.191, accompanied by a Shapiro-Wilk Statistic of 0.915, and both exhibit a significance level of 0.000 ($p < 0.001$). Based on the Kolmogorov-Smirnov and Shapiro-Wilk statistics, the normality tests also reveal significant deviation from a normal distribution ($p < 0.001$).

In summary, the normality tests indicate that the data for social interaction in all three groups (CT, PBBG, and CBG) significantly deviates from a normal distribution. This implies that the normality assumption is not met for social interaction data in these groups. Hence, an appropriate statistical method (Kruskall-Wallis test) was selected for non-normally distributed data when analyzing social interaction in these contexts.

Table 6.19 indicates the results of the Kruskall-Wallis test for mean scores of social interaction between CT, PBBG and CBG groups.

Table 6.19: Results of the Kruskall-Wallis test for mean scores of social interaction between CT, PBBG and CBG groups

Groups	**N**	**Mean Rank**	**df**	$\mathbf{x^2}$	***p***
CT	166	83.50	2	377.347	.000
PBBG	204	400.71			
CBG	204	340.29			

The results presented in Table 6.19 illustrate the outcomes of a Kruskal-Wallis test conducted to examine the mean scores of social interaction among the CT, PBBG, and CBG groups. The analysis involved 166 participants in the CT group, 204 participants in the PBBG group, and another 204 participants in the CBG group.

The findings reveal a significant difference in mean ranks among these groups, as indicated by the chi-square statistic ($x^2 = 377.347$) and the associated *p-value* ($p = 0.000$). This *p-value* is less than the significance level of 0.05, signifying a statistically significant difference in the mean scores of social interaction between at least two groups. Dunn's Post Hoc Test was conducted to investigate these group differences further.

Table 6.20 shows the results of Kruskal-Wallis Dunn's Post Hoc Test for mean scores of social interaction between CT, PBBG and CBG groups.

Table 6.20: Kruskal-Wallis Dunn's Post Hoc Test results for mean social interaction scores between CT, PBBG and CBG groups.

Post Hoc Test	**Chi-Square**	**Asymp. Sig. (2-tailed)**
CT vs. PBBG	297.462	.000
CT vs. CBG	213.946	.000
PBBG vs. CBG	13.331	.000

The results presented in Table 6.20 show the Kruskal-Wallis Dunn's Post Hoc Test outcomes, which were conducted to explore specific group differences in mean scores of social interaction between the CT, PBBG, and CBG groups.

When comparing the CT and PBBG groups, the chi-square statistic was 297.462, since the associated *p-value* was less than 0.001 ($p < 0.001$). This indicates a statistically significant difference in the mean social interaction scores between the CT and PBBG groups. In comparing the CT and CBG groups, the chi-square statistic was 213.946, and the *p-value* was less than 0.001 ($p < 0.001$). This suggests a statistically significant difference in mean social interaction scores between the CT and CBG groups. When comparing the PBBG and CBG groups, the chi-square statistic was 13.331, as the *p-value* was less than 0.001 ($p < 0.001$). This demonstrates a statistically significant difference in mean social interaction scores between the PBBG and CBG groups.

The post hoc test results indicate statistically significant differences in mean social interaction scores between all CT, PBBG, and CBG group pairwise combinations.

B. Classroom Observation

Two main themes were identified during the classroom observation: interactions between the researcher and participants and interactions among participants. From the first theme, several subthemes emerged, including (1) researcher-participant interaction, (2) types of questions, (3) participant questions, and (4) researcher's responses. Additionally, under the theme of "interaction among participants", the following subthemes were observed: (1) opportunity for participant interaction, (2) interaction style, (3) task collaboration, and (4) feedback provision. Figure 6.1 provides a summarized representation of these findings.

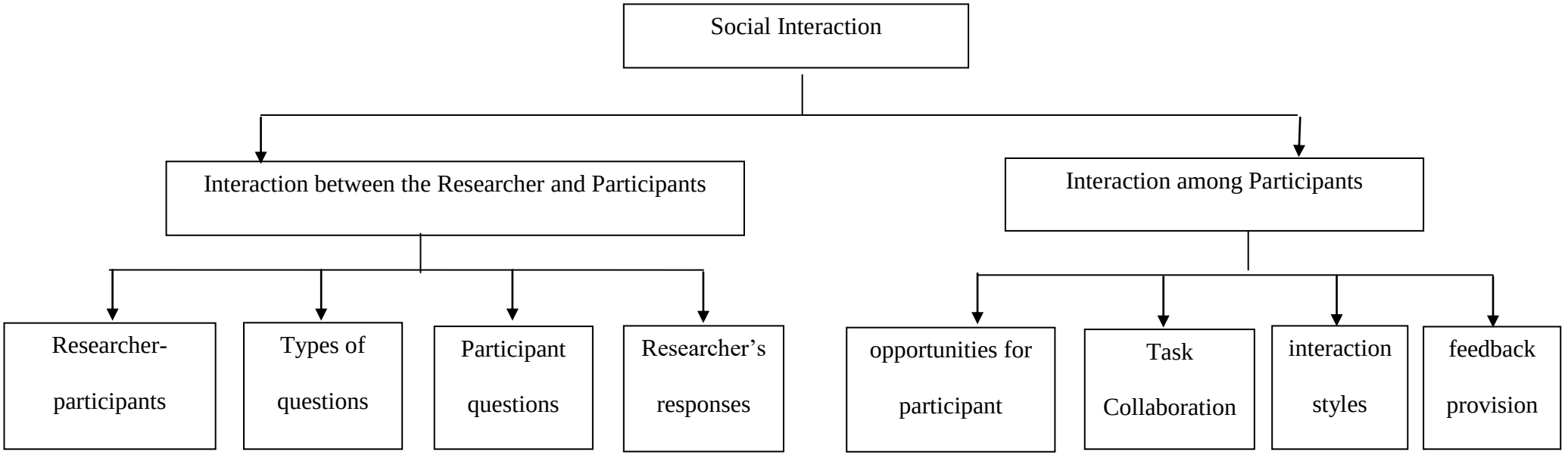


Figure 6.1: Themes and Its Subthemes for Social Interaction through Classroom Observation

Interaction between the Researcher and Participants

The findings indicated that most participants consistently interacted with each other during the observed Science classroom activities. The participants reported having ample opportunities to engage with the board games, PBBG and CBG, within their groups. They mentioned taking time for individual reflection before commencing the games in the classroom. Notably, the participants displayed excitement and active engagement with the researcher, as they were eager to experience the new learning methods, namely PBBG and CBG. Both the researcher and some participants provided feedback on this finding, which is as follows:

"*Teacher, what kind of games are we going to play later?*" *(PBBG G32P3)*

"*Later, we will learn a new topic through two versions of board games, namely 'SciFun Board Game'*". *(Researcher)*

Throughout the application of PBBG and CBG, the participants actively asked the researcher questions regarding the activity's content. Some participants were particularly curious about the gameplay and how to learn new knowledge while playing the board games effectively. The researcher capitalized on this opportunity and demonstrated how to play PBBG and CBG using PowerPoint presentations, dividing the participants into two groups in the classroom. Here is some feedback exchanged between the researcher and the participants:

"*Teacher, how to play the board game with other friends?*" *(PBBG G51P1)*

"*Teacher, how do we play and learn the new topic at the same time?*" *(CBG G11P4)*

"*Easy. Now, I am going show the rules of playing PBBG and CBG on the whiteboard. As we can see here*" *(Researcher)*

The researcher further engaged with the participants by asking them how the subtopic relates to the application of PBBG and CBG after the presentation. Many participants actively provided feedback, demonstrating their understanding of the board game rules. Their responses are as follows:

"*You all know how to learn new knowledge by playing this board game?*" *(Researcher)*

"*I don't know, teacher*" *(CBG G8P3)*

"*Okay, once you all play the board games, then you can learn the new knowledge by reading the questions and try to answer them within the allocated time*" *(Researcher)*

"*Okay, teacher. I will try it now.*" *(CBG G8P1)*

It was observed that the researcher tried to interpret and address the questions the participants raised while playing PBBG and CBG within their groups. The participants sometimes provided feedback to their teacher after receiving the instructions. This two-way communication between the researcher and participants enhanced the learning process while playing PBBG and CBG, as shown below:

"*Okay! Now you all know how to answer those questions while playing this board game?*" *(Researcher)*

"*Yes, teacher. I am trying to understand it deeply* " *(PBBG G23P2)*

"*Great! Seems like you all understand the rules of playing this board game and learn the new knowledge at the same time.*" *(Researcher)*

"*Okay, teacher. Thank you.*" *(PBBG G23P4)*

Interaction among Participants

According to the co-observer's statements, the classroom participants' interaction was highly active, as they consistently communicated with each other while playing PBBG and CBG. This active communication indicated that the participants engaged in discussions with their group members, contributing to the success of the PBBG and CBG activities. All the participants had equal opportunities to learn new knowledge about the selected Science topics. Some of the responses from the participants while playing PBBG and CBG are as follows:

"*Now it is your turn to roll the dice and pick the slot.*" *(PBBG G33P1)*

"*Okay, let me think first about this question.*" *(PBBG G8P4)*

"*Wow! This question is easy! I can answer it!* "(*CBG G37P4)*

"*Sorry, your answer is incorrect! The answer is C!* "(*CBG G9P1)*

"*Now, who is leading the scoreboard?*" *(PBBG G7P2)*

"*How lucky I am to get this slot!*" *(CBG G3P3)*

During the observation, it was evident that the participants interacted with each other while filling in the points obtained by their group members on the scoreboard, whether they were playing PBBG or CBG. They engaged in discussions when a group

member failed to answer a question within the allocated time, using the opportunity to collectively learn and understand the new knowledge. Some of the responses noted during this interaction are as follows:

"*You know how to play this board game? I can explain to you.*" *(PBBG G50P1)*

"*I am not sure how to use it. Teach me.*" *(PBBG G50P2)*

"*Your turn to roll the dice! Let's see what number you will get?*" *(PBBG G50P3)*

"*Yes, you get '5'! You get 'LUCK' slot! This is the question you get. Let me help you to read it out! "(PBBG G50P4)*

During the observation, it was evident that the participants interacted with each other while filling in the points obtained by their group members on the scoreboard, whether they were playing PBBG or CBG. They engaged in discussions when a group member failed to answer a question within the allocated time, using the opportunity to collectively learn and understand the new knowledge. Some of the responses noted during this interaction are as follows:

"*What is your score? Let me help you to fill!*" *(CBG G28P2)*

"*Okay, I get 2 marks for this question. Thanks ya!*" *(CBG G28P1)*

"*I fail to answer this question. Can we discuss now?*" *(CBG G37P3)*

"*Sure, no problem! Let's do it!*" *(CBG G37P2)*

The co-observer noted that the participants consistently interacted with each other to determine the final winner after playing PBBG and CBG in the classroom. They

engaged in discussions and shared their experiences during the game. Some of the responses observed and recorded are as follows:

"*Hey! Let's find out who is the winner for this PBBG today?*" *(PBBG G41P4)*

"*Okay! Let's do it now!* "*(PBBG G41P2)*

"*Wow! The winner is Participant 3!* "*(PBBG G28P1)*

"*Yes! I win!* "*(PBBG G28P3)*

Based on the provided observations, there do not appear to be significant discrepancies or variations in the feedback provided by participants during classroom observation. The researcher actively engaged with participants, providing explanations and guidance on how to play the board games (PBBG and CBG) and learn new topics simultaneously. Participants showed enthusiasm and curiosity about the learning methods, asking questions and seeking clarification from the researcher. The researcher responded by demonstrating game rules and encouraging participation, fostering a positive learning environment. Participants interacted with each other during gameplay, discussing questions, strategizing, and helping each other understand the content. There was active communication within groups, with participants taking turns, discussing answers, and supporting each other's learning. This interaction facilitated collective learning and understanding among participants. Meanwhile, participants engaged in discussions to determine the final winner after playing the board games. They shared experiences, celebrated victories, and demonstrated sportsmanship, indicating a collaborative and supportive learning environment. Overall, the interactions between the researcher and participants, as well as among participants themselves, were characterized by active

engagement, collaboration, and mutual support, contributing positively to the learning process. There were no notable discrepancies or variations in the feedback provided, suggesting consistent experiences across the observed classroom activities.

C. Interview

This research utilized the six-phase analytical process proposed by Braun and Clarke (2006) to identify social interactions among 10-year-old participants. The logical and sequential organization of the six phases allowed the researcher to focus on qualitative analysis, recognizing that it is not a linear process moving forward through the phases (Byrne, 2022).

Phase One: Familiarisation with the Data

Transcription is crucial in data analysis, particularly using a qualitative methodology (Braun & Clarke, 2006). The transcriptions of study participant interviews were prepared and double-checked immediately after the interview sessions. However, the researcher took the time to familiarize with the social interaction features beyond simply transcribing verbal data into written form. All audio recordings were carefully listened to, and the transcripts were read at least once to make notes on the data. This initial engagement with the social interaction features among 10-year-old participants, after utilizing PBBG and CBG, led to the emergence of preliminary themes throughout the data set. Examples of transcripts from a few participants who attended the interview session are shown in **Appendix AE**.

Phase Two: Generating Initial Codes

Phase 2 commonly begins with a systematic analysis of the data through coding. These codes have been referred to as the building blocks of thematic analysis, as they aim to provide a label for a feature of the data related to Research Question 5. As previously mentioned, the codes were data-driven, and a preview of different types of codes and their applications has been prepared. The code-generating step was imbued with cyclic, iterative cycles of organizing data into meaningful groups (Xu & Zammit, 2020), as finding out which data set to begin with was crucial.

In this research, the participants' social interaction while applying PBBG and CBG has been interpreted to produce different themes from the interview method into the form of transcripts. As suggested by Saldana (2016), the transcripts were read line by line, and the raw information was reduced into smaller units to identify themes within those 10-year-old participants. Examples of coded transcripts for a few participants during the interview sessions, are shown in **Appendix AE**.

Phase Three: Generating Themes

The searching for themes step includes considering how relevant codes could be sorted, collated, and combined (Nowell et al., 2017) to create an overarching theme for social interaction features among participants aged 10 after implementing PBBG and CBG in the Science classroom. The participants' opinions toward social interaction features for the application of PBBG and CBG were coded and conflated so that potential themes emerged. Corresponding to this phase, the coded data were reviewed to determine the areas of similarity and overlap between codes, as this research has involved the themes using all

the codes related to the participant's experience of social interaction while utilizing PBBG and CBG in the Science classroom. Some codes with illustrative data extracts from the research participants, are shown in **Appendix AE**.

Phase Four: Reviewing Potential Themes

The next phase is commonly characterized by reviewing and refining the themes as the researcher returns to the raw data and applies the "compare-and-contrast" method to develop the themes (Rathbone et al., 2023). This reviewing phase includes the step of reading and ascertaining that the data extracts form coherent themes so that the meanings in the data set are accurately represented. If some themes for social interaction features while utilizing PBBG and CBG are realized against the collated data extracts during the interviews, their codes could be discarded or relocated under another theme. Once a distinctive and coherent set of themes that work with the coded data extracts is identified, they are undertaken into the second stage of the review process. Hence, the researcher spent time re-reading all the data to determine those themes meaningfully, as the most important and relevant elements of the data extracts can be captured and relevant to the research question in Chapter 1. Below are certain codes, and the corresponding themes have been reviewed in Table 6.21-

Table 6.21: Definition and Labels for Selected Themes

Definition and Labels for Selected Themes
Theme 1: Work Collaboratively
This theme has outlined the collaboration work between group members that apply PBBG or CBG, respectively. Undeniably, the majority of the respondents during the

interview session shared the same opinions, as they were willing to work collaboratively in the Science classroom and conduct the learning process. Hence, it was assumed that those research participants preferred interacting with other group members while collaborating in the classroom.

Theme 2: Playing Board Games with Friends

During the interview sessions with those research participants, most preferred using PBBG or CBG with their friends while learning Science in the classroom. Additionally, they were willing to be involved in implementing both versions of board games so that they could play and learn with friends simultaneously. Thus, they have positive social interaction with each other in making the board games successfully.

Theme 3: Engagement

Regarding the theme of engagement for social interaction, it was realized that most of the group members, regardless of applying PBBG or CBG with CL, agreed with the statement that they preferred to engage in a group activity. Furthermore, they were willing to discuss Science questions while conducting both types of board games so that they could learn and master the relevant Science knowledge in the classroom. Hence, this scenario indicates that a positive engagement has been identified among the group members during PBBG and CBG implementation with CL.

Theme 4: Group Involvement

The theme of group involvement has been incorporated, as most of the research participants preferred communicating with other group members while using both versions of board games in the Science classroom. According to the interviewees, they

Table 6.21 Continued

were given many opportunities to communicate with each other, which allowed them to play and learn Science knowledge simultaneously. Therefore, this scenario indicates that active group involvement was observed, resulting in positive social interaction among the research participants with implementing PBBG and CBG.

Phase Five: Defining and Naming Theme

This phase aimed to determine the essence of each theme for the social interaction features among 10-year-old participants after playing PBBG and CBG in the Science classroom. It was crucial to organize the themes into a coherent and consistent account (Braun & Clarke, 2006) to avoid overlapping issues during the thematic analysis. For example, in this phase, the focus was on the learning motivation between the two participant groups that utilized PBBG and CBG. At the end of this step, it was recommended to name the themes concisely and precisely for later analysis. Below are some excerpts based on the themes identified in the thematic analysis of the interviews among 10-year-old participants.

Theme 1: Work Collaboratively

In line with other participants, the research participants expressed their willingness to work collaboratively rather than individually in the Science classroom when using PBBG and CBG. As PBBG G27P2 described this quite evocatively: "We enjoyed working together, it was more fun and we learned from each other:

Okay. Do you like to work individually or collaboratively..? Can you tell me why? (Researcher)

After…emm…playing this board games…I think I always to work hmm…collaboratively as four of us form a team and play it… (PBBG G27P2)

PBBG G27P2, for instance, took the comment "*playing this board games…I think I always to…work… Hmm…collaboratively…*" as strong evidence of a potential positive response to his willingness to conduct work collaboratively.

Furthermore, another participant who used PBBG also stated that it was better to work collaboratively while learning Science in the classroom, as mentioned by PBBG G50P1.

Yup, I am personally like to…hmm….work collaboratively…It is… ehmm…because we can learn Science concepts together…while having fun to play this board game… (PBBG G50P1)

After analysing the responses from this participant, it became evident that learning Science collaboratively allows them to master it better and have fun playing PBBG with other group members.

It was supported by the statement from research participants who applied CBG with CL in the Science classroom, as mentioned by CBG G32P1:

Of course, teacher! I think that I like to work collaboratively in the classroom… It is because a lot of fun when I am playing and learning with my friends through…ehmm…this kind of board game… (CBG G32P1).

Undeniably, participants who applied CBG with CL also mentioned that they had much fun playing and learning with their friends as they were allowed to work

collaboratively. Another study participant, CBG G23P2, agreed that working collaboratively allowed them to learn and play together, which helped them master Science knowledge better.

Yes…I am more….hmm….prefer to work collaboratively…It is… because…ah…I can learn and play together with my friends…as we can master that Science knowledge in a better way (CBG G23P2).

Theme 2: Playing Board Games with Friends

Theme 2, Playing Board Games with Friends, has been identified, as most participants described that they preferred to apply either PBBG or CBG, with their friends in the Science classroom. For example, PBBG G40P3 and PBBG G33P1 have supported the statement.

Yes….absolutely…I really like to use…ehmm…this kind of board game with my friends because I like to learn the Science… ehmm…knowledge through gaming method…as this board game is... really interesting to play… (PBBG G40P3)

Yes, I do! I like…ehmm….to apply Paper-Based Board Games…ah… and play with my friends…It can provide me much time and learn… hmm…together with them. (PBBG G33P1)

Overall, the participants who used PBBG agreed they liked to use PBBG while playing and learning with their friends, as it was much more fun for them during their group activities in the Science classroom.

The interviewer also observed that implementing CBG with CL resulted in similar perceptions among the research participants, as they also preferred to use CBG with their

friends in the Science classroom. For instance, CBG G51P1 shared her comments expressing her preference for using CBG with her friends during the learning process.

So, do you like to use Computerised Board Games with your friends? Why? (Researcher)

Ehmm….yup…I think I like to use this computerized board game…especially with my friends…it is because playing with them, then I… hmm…can learn and master those scientific skills better… (CBG G51P1)

The responses from another CBG participant, CBG G16P3, supported it.

Absolutely, teacher…I like to play computerized board games…with my friends…because this scenario allows us to play and learn in a fun way… (CBG G16P3)

It is concluded that PBBG and CBG participants liked using those board games with their group members or friends in the Science classroom. They wanted to have fun while learning new knowledge, indicating a positive attitude towards CL with the board games.

Theme 3: Engagement

The third theme, "Engagement for Social Interaction" has been selected by the researcher, as both PBBG and CBG groups were given the opportunities to engage in group activities, especially to discuss Science questions. For instance, one of the participants, PBBG G10P3, shared her perception during the interview.

So, do you like to engage in a group activity to discuss Science questions? Why? (Researcher)

Yup…I always prefer to…emm….engage in group activity. So, I… can also discuss the Science question with my group members too…hmm…the Science question. (PBBG G10P3)

Another participant from the PBBG group, PBBG G40P3, also agreed with the statement, as he preferred to engage in a group activity like PBBG to discuss Science questions.

Yes…for me, I like to engage with my friends in the group activity, as … hmm….we can discuss those Science questions while playing this board game in the classroom…It is because playing within group is… hmm…more interesting and enjoyable (PBBG G40P3)

PBBG participants had the same perception as most research participants, as they like to engage in group activities to socialize with their friends while learning new knowledge in Science topics through implementing PBBG in the classroom.

During the interview, another group commented on their perception of implementing CBG with CL. CBG G44P4, for instance, has shared her feedback after playing CBG in the Science classroom.

Yes…I always like to engage…ehmm….in a group activity…so that we can discuss those Science questions….Furthermore, we can play and then…ehmm…learn together with this board game in the class (CBG G44P4).

CBG G51P1 also commented that the engagement in group activities was positive for him to discuss Science questions with other group members while playing CBG with CL.

Yup…as I know, I am an active person…so I can engage in a group activity with my group members…so that we can be together and… emm…discuss the Science questions…Hence, it is better for us to do like this. (CBG G51P1)

PBBG and CBG groups have similar perceptions, as they were willing to engage in group activities, particularly board games, to discuss questions among the group members to have an interesting and fun learning experience.

Theme 4: Group Involvement

The fourth theme, group involvement, has been included in this section on social interaction, as it involves the two distinct groups, PBBG and CBG groups. As mentioned by PBBG G27P2, he supported the application of PBBG for Learning Science.

Then, do you like to communicate with other group members while you are involved in using these board games? Why? (Researcher)

Hmm…yes…I think I like to do it…as we can have the chances…emm… to communicate while using these board games…so that we can solve… hmm…the Science questions together…It is a lot of fun with them! (PBBG G27P2)

Another PBBG participant, PBBG G33P1, also mentioned that she likes to communicate with her group members when she is involved in using PBBG in the classroom.

Yes… I always prefer to… hmm….communicate with other group members…especially when we are..ah…using this board game….so that…we can enjoy the learning environment and master…. hmm… the knowledge better… (PBBG G33P1)

It can be concluded that most of the participants in the PBBG groups preferred to communicate with their group members while using PBBG together to enjoy the learning environment in the classroom. Similarly, other CBG participants, CBG G23P2 and CBG G32P1, shared that they liked communicating with other group members while playing CBG together.

Yes…of course…I like to communicate with others when we are… ehmm…using this computerized board game because I can receive other ideas from them at that moment… (CBG G23P2)

Of course…I prefer to communicate with…hmm...other group members, especially…hmm…when we apply this…. ehmm…computerized board game….It is because we can discuss with each other and then master that knowledge better (CBG G32P1)

It can be said that both PBBG and CBG groups preferred to communicate with their group members while those board games were implemented in the classroom so that they could learn the knowledge in a funnier environment.

Phase Six: Producing the Report

The themes emerging from the data and interview transcripts were analyzed and discussed. Hence, it is pragmatic to embed the participants' voices to demonstrate the rigor of the themes, as the report should revolve around selected examples capturing the essence of the data with quotes directly from research participants, who were 10-year-old participants in the Science classroom (Fereday & Muir-Cochrane, 2006). Additionally, some quotes were selected as they were prevalent throughout the transcripts and particularly representative of many voices, as their uniqueness in pointing out a fresh new

point of view about the individual social interaction after utilizing PBBG and CBG. The report incorporated the quotes from interviews, as they can be supported by literature conceptually (Yin, 2018) so that the data can be enriched and create a compelling argument with the research question of this research (Clarke & Braun, 2014).

The themes under Collaboration answered the research questions relevant to the social interaction features in learning Science using PBBG and CBG among 10-year-old participants. Those participants were asked to give feedback about the teamwork they can contribute, as they like to work collaboratively, or vice versa. Another sub-theme of collaboration is playing board games with friends, as the participants enjoy PBBG and CBG in learning Science. Most of them expressed their opinions after playing both versions of board games in the Science classroom.

Communication code was selected as another main section for social interaction while the interview was conducted. Hence, engagement was one of the main sub-themes, as the participants could discuss Science questions while playing PBBG and CBG in the classroom. Additionally, group involvement is also important to emphasize in this research, as those participants can have the chance to communicate with their group members while learning new knowledge through the implementation of PBBG and CBG. When their thoughts were asked about their communication opportunities, most participants answered that they always talked to each other while playing board games.

Referring to the feedback from those 10-year-old participants, there do not seem to be any significant discrepancies or variations between the feedback provided by participants during classroom observation. The thematic analysis reveals consistent responses across different participants and groups. Participants across both PBBG and CBG groups expressed a preference for collaborative work in the classroom. They enjoyed

working together, found it more fun, and believed they learned from each other. This theme was consistent across various participant responses, indicating a shared positive attitude towards collaborative learning. Another common theme was the preference for playing board games with friends. Participants from both PBBG and CBG groups mentioned enjoying using these games with their friends, finding it interesting and enjoyable. Again, this sentiment was consistent across different responses, suggesting a widespread positive perception of learning through board games with peers. Participants expressed a desire for engagement in group activities, particularly to discuss science questions while playing board games. They believed that engaging in group activities facilitated learning and made the process more enjoyable. This theme was evident across various participant responses, highlighting the importance of engagement for effective learning. Then, participants valued communication and involvement with their group members while using board games in the classroom. They believed that communicating with peers helped them solve science questions together and created a more enjoyable learning environment. This theme was consistent across both PBBG and CBG groups, indicating a shared appreciation for collaborative learning. Overall, the thematic analysis suggests consistent feedback from participants regarding their experiences with PBBG and CBG in the classroom. The themes identified align with positive attitudes towards collaborative learning, engagement, and group involvement, indicating a cohesive understanding of the benefits of using board games for learning science among the participants.

The significant results of the research shed light on the impact of different teaching methods, particularly those incorporating CL, on social interaction in the science classroom among 10-year-old participants. The research highlights the importance of

fostering social interaction in the science classroom, as it is associated with effective teaching methods such as CL. By demonstrating that CL methods, including PowerPoint presentations, PBBG, and CBG, stimulate social interaction among students, the study suggests that addressing this aspect could contribute to improving international rankings by creating more engaging and interactive learning environments.

The findings emphasize the role of teaching methods in promoting social interaction, which can help address the lack of understanding, misconceptions, and educational challenges prevalent in traditional teaching approaches. By encouraging collaboration and interaction among students, CL methods like PBBG and CBG provide opportunities for peer learning and clarification of misconceptions, potentially leading to improved academic performance in science subjects. The preference expressed by participants for applying board games with their friends highlights the motivational aspect of social interaction in the learning process. By fostering a sense of enjoyment and engagement through collaborative activities, CL methods can potentially overcome the barrier of low motivation among students, thereby enhancing their overall learning experience and academic performance.

The research underscores the potential of PBBG and CBG, particularly when combined with CL, to address the scarcity of interactive and collaborative learning resources tailored for science education in Chinese primary schools. By demonstrating the effectiveness of these methods in stimulating social interaction and engagement, the study provides valuable insights into how such resources can be integrated into science curricula to enhance student learning outcomes. The findings support the potential of PBBG and CBG to address the shortcomings of traditional teaching methods and digital games by providing hands-on, interactive, and collaborative learning experiences. By highlighting

the positive impact of these methods on social interaction in the science classroom, the research underscores their importance in creating dynamic and engaging learning environments conducive to effective science learning.

Hence, the results affirm the relevance of the problem statements by demonstrating how different teaching methods, particularly those emphasizing social interaction through CL, can address the identified challenges in science education. By providing evidence of the effectiveness of these methods in promoting social interaction among students, the research validates the importance of addressing this aspect in efforts to improve science learning outcomes.

6.3.4 How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

A. Questionnaire

One hundred sixty-six participants aged 10 were given the questionnaires to complete after implementing the CT in the Science classroom. Table 6.22 provides information about the sample sizes and the corresponding interpretations of mean scores for the CT, PBBG, and CBG groups based on the first dimension of learning motivation, "Self-Challenge," following the approach outlined by Degang (2010).

Table 6.22: Mean Score Interpretation for Learning Motivation (Self-Challenge) in Learning Science using CT, PBBG and CBG among 10-year-old participants

Dimension	Groups	Average Mean Score	SD	Interpretation
Self-Challenge	CT	2.93	.489	Moderate
	PBBG	4.77	.256	Very high
	CBG	4.75	.263	Very high

Based on Table 6.22, a comparison of the average mean scores and standard deviation was conducted for CT group (Mean=2.93, SD=0.489), PBBG group (Mean=4.77, SD=0.256) and CBG group (Mean=4.75, SD=0.263), reveals different interpretation. This score falls within the "Moderate" interpretation for the CT group, indicating a moderate self-challenge in learning science among the participants. For the PBBG group, the score is categorized as "Very high," suggesting a high level of self-challenge in learning science within this group of participants. In the CBG group, the score also falls into the "Very high" interpretation category, indicating a high level of self-challenge in learning science within the CBG group participants.

In summary, the data suggests that participants in both the PBBG and CBG groups exhibit a very high level of self-challenge in learning science compared to those in the CT group, who demonstrate a moderate level of self-challenge dimension.

Table 6.23 provides an overview of the number of participants and the associated interpretations of mean scores based on Degang (2010) for the CT, PBBG, and CBG groups, focusing on the second dimension of learning motivation, "Self-Confidence."

Table 6.23: Mean Score Interpretation for Learning Motivation (Self-Confidence) in Learning Science using CT, PBBG and CBG among 10-year-old participants

Dimension	Groups	Average Mean Score	SD	Interpretation
Self- Confidence	CT	2.80	.568	Moderate
	PBBG	4.79	.219	Very high
	CBG	4.66	.251	Very high

According to Table 6.23, the participants achieved an average mean score of 2.80 in the CT group with a standard deviation of 0.568. This indicates a "Moderate" level of self-confidence in their learning motivation. Conversely, the PBBG group attained an average mean score of 4.79 with a standard deviation of 0.219, signifying a "Very high"

level of self-confidence in their learning motivation. Similarly, the CBG group achieved an average mean score of 4.66 with a standard deviation of 0.251, indicating a "Very high" level of self-confidence in their learning motivation.

In summary, the data reveals significant differences in self-confidence among these groups, with the PBBG and CBG groups demonstrating notably higher levels of self-confidence dimension compared to the CT group.

Table 6.24 provides information on the number of participants and their corresponding mean score interpretations based on Degang's (2010) framework. The analysis is centered on the third dimension of learning motivation, "Assessment," including the CT, PBBG, and CBG groups.

Table 6.24: Mean Score Interpretation for Learning Motivation (Assessment) in Learning Science using CT, PBBG and CBG among 10-year-old participants

Dimension	Groups	Average Mean Score	SD	Interpretation
Assessment	CT	2.91	.433	Moderate
	PBBG	4.88	.092	Very high
	CBG	4.84	.110	Very high

Based on Table 6.24, the participants of the CT group have an average mean score of 2.91 with a standard deviation of 0.433, indicating a "Moderate" level of motivation in the dimension of Assessment. For the PBBG group, the average mean score is 4.88 with a standard deviation of 0.092, signifying a "Very high" level of motivation in the Assessment dimension. Participants in the CBG group have an average mean score of 4.84 with a standard deviation of 0.110, indicating a "Very high" level of motivation in the Assessment dimension.

These findings suggest that the PBBG and CBG groups exhibit very high motivation in the Assessment dimension compared to the CT group, which shows moderate motivation.

Table 6.25 details the number of participants included and the associated mean score interpretations based on the fourth dimension, learning motivation, using the Degang (2010) scale for the CT, PBBG, and CBG groups.

Table 6.25: Mean Score Interpretation for Learning Motivation Dimension in Learning Science using CT, PBBG and CBG among 10-year-old participants

Dimension	Groups	Average Mean Score	SD	Interpretation
Learning Motivation	CT	2.86	.460	Moderate
	PBBG	4.87	.110	Very high
	CBG	4.80	.130	Very high

According to Table 6.25, the participants in the CT group had an average mean score of 2.86 with a standard deviation of 0.460. This suggests a moderate level of learning motivation in this group. The PBBG group had an average mean score of 4.87 with a standard deviation of 0.110, indicating a very high level of learning motivation among participants in this group. Similarly, the CBG group exhibited a very high level of learning motivation; with an average mean score of 4.80 and a standard deviation of 0.130.

These findings highlight differences in the levels of learning motivation dimension between the three groups, with the PBBG and CBG groups showing notably higher motivation levels than the CT group.

Table 6.26 provides an overview of the number of participants and their mean score interpretations based on Degang (2010) for the CT, PBBG, and CBG groups, considering learning motivation. Every participant exhibited moderate mean scores when employing CT as their learning tool. These findings suggest that PowerPoint Presentations moderately

impacted the participants' learning motivation, as indicated by the moderate average mean score in this research. Notably, all research participants displayed significantly high mean scores after utilizing PBBG as a learning tool in the context of learning Science. Subsequently, all research participants demonstrated significantly elevated mean scores following their engagement with CBG as an educational tool in learning Science.

Table 6.26: Mean Score Interpretation for Learning Motivation in Learning Science using CT, PBBG and CBG among 10-year-old participants

Aspect	Groups	Average Mean Score	SD	Interpretation
Learning Motivation	CT	2.87	.643	Moderate
	PBBG	4.85	.368	Very high
	CBG	4.79	.409	Very high

Based on Table 6.26, participants in the CT group displayed a moderate mean score of 2.87 with a standard deviation of 0.643. This indicates a moderate learning motivation among these participants when using PowerPoint Presentations as their learning tool. Participants in the PBBG group exhibited a very high mean score of 4.85 with a standard deviation of 0.368. These results indicate a significantly high level of learning motivation among those who engaged with paper-based board games as a learning tool in learning Science. In the CBG group, participants achieved an average mean score of 4.79, with a standard deviation of 0.409. Like the PBBG group, this suggests a very high level of learning motivation among the participants who utilized computerized board games for their Science learning.

The PBBG and CBG groups demonstrated very high learning motivation, while the CT group showed moderate learning motivation.

Table 6.27 shows the results of normality tests for learning motivation after using CT, PBBG and CBG among the 10-year-old participants in the classroom.

Table 6.27: Tests of Normality for Learning Motivation after Implementing CT, PBBG and CBG among the 10-year-old participants

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CT	.213	166	.000	.903	166	.000
PBBG	.241	204	.000	.876	204	.000
CBG	.179	204	.000	.919	204	.000

Referring to Table 6.27, for the CT group, the Kolmogorov-Smirnov Statistic is 0.213 with a significant p-value of 0.000 ($p < 0.001$). The Shapiro-Wilk Statistic is 0.903 with a significance level 0.000 ($p < 0.001$). These results indicate that the learning motivation data in the CT group significantly deviates from a normal distribution.

In the PBBG group, the Kolmogorov-Smirnov Statistic is 0.241 with a significant p-value of 0.000 ($p < 0.001$). The Shapiro-Wilk Statistic is 0.876 with a significance level 0.000 ($p < 0.001$). This suggests that the learning motivation data in the PBBG group also significantly departs from a normal distribution.

For the CBG group, the Kolmogorov-Smirnov Statistic is 0.179 with a significant p-value of 0.000 ($p < 0.001$). The Shapiro-Wilk Statistic is 0.919 with a significance level 0.000 ($p < 0.001$). Similarly, the learning motivation data in the CBG group significantly deviates from a normal distribution.

Overall, the learning motivation data for all three groups (CT, PBBG, and CBG) deviates significantly from a normal distribution, as indicated by the low p-values in both normality tests. This suggests that the non-parametric statistical test (Kruskall-Wallis test) was more appropriate for analyzing this data due to its departure from normality.

Table 6.28 indicates the Kruskall-Wallis test results for mean learning motivation scores between CT, PBBG and CBG groups.

Table 6.28: Results of the Kruskall-Wallis test for mean scores of learning motivation between CT, PBBG and CBG groups

Groups	**N**	**Mean Rank**	**df**	x^2	***p***
CT	166	83.50	2	378.260	.000
PBBG	204	409.82			
CBG	204	331.18			

Table 6.28 presents 166 participants in the CT group, 204 participants in the PBBG group, and another 204 participants in the CBG group. The Kruskal-Wallis statistic (chi-square) is 378.260 with 2 degrees of freedom, and the p-value associated with this test is less than 0.001 ($p < 0.001$). The *p-value* indicates a statistically significant difference in learning motivation mean scores among the participants of the three groups.

In summary, the Kruskal-Wallis test reveals a statistically significant difference in learning motivation mean scores among the participants in all three groups: CT, PBBG, and CBG. The p-value for the test is highly significant ($p < 0.001$), indicating that the differences are not likely due to random chance.

Table 6.29 shows the results of Kruskal-Wallis Dunn's Post Hoc Test for mean learning motivation scores between CT, PBBG and CBG groups.

Table 6.29: Kruskal-Wallis Dunn's Post Hoc Test results for mean learning motivation scores between CT, PBBG and CBG groups.

Post Hoc Test	**Chi-Square**	**Asymp. Sig. (2-tailed)**
CT vs. PBBG	297.462	.000
CT vs. CBG	287.911	.000
PBBG vs. CBG	27.578	.000

Table 6.29 presents the results of the Kruskal-Wallis Dunn's Post Hoc Test, which was conducted to explore further the differences in mean learning motivation scores among the three groups.

To compare CT and PBBG groups, the Chi-Square statistic for comparing the CT and PBBG groups is 297.462, and the associated *p-value* is less than 0.001 ($p < 0.001$). This result indicates a statistically significant difference in mean learning motivation scores between the CT and PBBG groups.

When comparing the CT and CBG groups, the Chi-Square statistic is 287.911, since the p-value is less than 0.001 ($p < 0.001$). This shows a statistically significant difference in mean learning motivation scores between the CT and CBG groups.

For the comparison between PBBG and CBG groups, the Chi-Square statistic is 27.578, and the p-value is less than 0.001 ($p < 0.001$). This result reveals a statistically significant difference in mean learning motivation scores between the PBBG and CBG groups.

Overall, Kruskal-Wallis Dunn's Post Hoc Test results indicate statistically significant differences in mean scores of learning motivation among all possible pairs of the three groups: CT, PBBG, and CBG. The *p-values* for each pair are highly significant ($p < 0.001$), demonstrating that these differences are not likely due to random chance.

B. Classroom Observation

The observation and reflective notes encompassed two main themes: the lesson structure and use of technology, devices, or resources, and other observations. From these main themes, two sub-themes emerged: (1) "Classroom situation at the beginning, middle,

and end" and (2) "Researcher-participant activities" were under the lesson structure theme. Additionally, under the theme of the use of technology, devices, or resources, there were five sub-themes: (1) "The possibility of technology, device, or resources being used as parts of the activity," (2) "Usage method and purpose," (3) "Issues faced by researcher or participants," (4) "Troubleshooting capability," and (5) "Additional resources/devices employed by the researcher." Figure 6.2 illustrates each theme and its corresponding sub-themes.

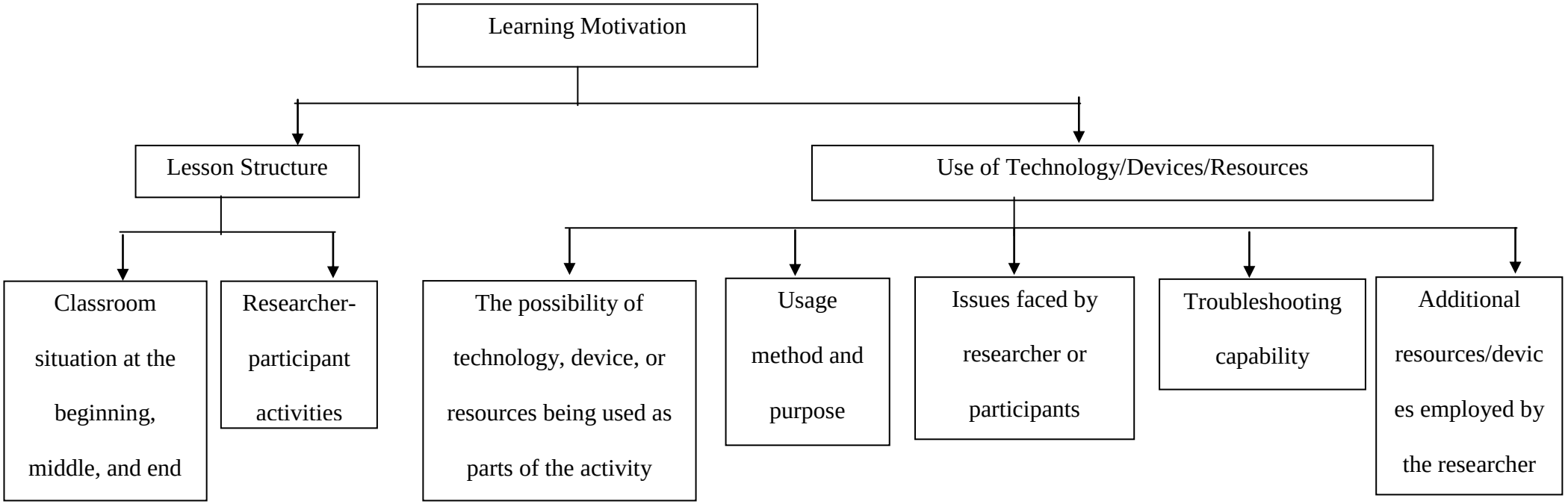


Figure 6.2: Themes and Its Subthemes for Learning Motivation through Classroom Observation

Lesson Structure

The lesson's structure was focused on the classroom situation at the beginning, middle, and end stages. The researcher commenced the lesson by explaining the activities to the participants and encouraging them to ask questions about the learning content. PBBG and CBG were distributed to the participants before the lesson began, and instructions for playing both versions of the board games were provided. During the lesson, the participants engaged in the simultaneous play of PBBG and CBG, with the researcher monitoring their progress and occasionally offering targeted assistance.

Upon concluding the activity, the researcher informed the participants about the next lesson before dismissing the class. Feedback from both the researcher and the participants was recorded, capturing their thoughts and observations during the learning processes as follows:

"It is time for you all to play PBBG while learning the subtopic 'Reflection of Light'". (Researcher)

"Great! Now it is your turn to roll the dice and open the slot you select later." (CBG G34P3)

"Teacher, what should I do next?" (PBBG G45P1)

Use of Technology/Devices/Resources

During the observation, it was noted that the researcher utilized PowerPoint presentations to provide instructions for playing PBBG and CBG. A laptop and projector were also used to display the "Time Countdown" on the whiteboard, allowing the participants to play PBBG and CBG within the specified time.

The researcher actively incorporated technology and relevant resources with the participants as integral parts of the activity. However, some challenges were encountered, particularly with participants unfamiliar with using laptops and playing board games. The researcher had to provide extra attention and support to ensure that the process of applying CBG was successful for all participants. It was observed that some of the participants could troubleshoot independently, assisting their group members who faced difficulties completing the board game using a laptop.

Various observations were made throughout the process, and the researcher and participants' responses were recorded for further analysis as follows:

"You all can refer to the slides that I show in front of this whiteboard."(Researcher)

"Teacher, for how long can we play this board game?" (CBG G22P1)

"As you all can see here, the duration of playing PBBG and CBG is 30 minutes." (Researcher)

"Participant 2, do you know how to relate this one?" (PBBG G37P3)

"Okay, class. You still have 23 minutes to play!" (Researcher)

There were no significant discrepancies or variations between the feedback provided by participants during classroom observation regarding the lesson structure and the use of technology or resources. The observations highlight a consistent engagement with the activities and the researcher's instructions. The lesson followed a structured format, beginning with explanations of activities, distribution of materials, and instructions for playing PBBG and CBG. Participants engaged in simultaneous play, and the researcher monitored their progress while occasionally offering assistance. Feedback from both the

researcher and participants was recorded, indicating an interactive and communicative learning environment. The interactions captured during the lesson demonstrated active participation and engagement from both parties, with participants seeking clarification when needed. The researcher effectively utilized technology, such as PowerPoint presentations and a laptop with a projector, to facilitate the activities. The use of a "Time Countdown" on the whiteboard helped manage the duration of gameplay. While some participants faced challenges with unfamiliar technology, the researcher provided extra support to ensure successful participation. Additionally, participants demonstrated problem-solving abilities, assisting their peers when needed. Overall, the observations suggest a proactive approach to addressing technological challenges and ensuring an inclusive learning experience. In summary, the feedback provided by participants during classroom observation indicates a consistent understanding and engagement with the lesson structure and the use of technology/resources. Any variations observed seem to have been effectively addressed by the researcher, resulting in a cohesive learning environment.

C. Interview

The chosen approach for thematic analysis in this research is the six-phase approach by Braun and Clarke (2006). During the initial phase of data familiarization, a detailed examination of the interview sessions was conducted to gain deeper insights into the learning motivation between the researcher and the research participants after implementing PBBG and CBG in the Science classroom.

Efforts were made to streamline the coding process, aiming for quicker and easier coding while operating at a more conceptual level. This allowed for the development of

themes faster and more confidently, reducing the need for extensive reviewing. This approach proved particularly useful when working with a smaller data set obtained from the interview sessions in this research.

Phase One: Familiarisation with the Data

In this initial phase of thematic analysis, the focus was on immersing in the data by thoroughly reading and rereading the interview transcripts relevant to the learning motivation of the 10-year-old participants after implementing PBBG and CBG in the Science classroom. Moreover, the audio recordings of the interviews were listened to once while simultaneously reviewing the interview transcripts, ensuring comprehensive data coverage.

The researcher actively, analytically, and critically digested the words and their meanings from the interview transcripts. It was of utmost importance to become familiar with the data set's contents and note any significant aspects that might be related to the research question posed in this research. This phase allowed for a deep understanding of the participants' perspectives and motivations, forming the foundation for subsequent analysis and theme development, such as "What are the learning motivations of 10-year-old participants affected by PBBG and CBG, with CL in the Science classroom?" Other interview transcripts from several respondents can be seen in **Appendix Z**. Below are two selected interview transcripts: -

Ah-ha. I think I can understand the content when I apply these board games. It is because I can play and learn… emm.. at the same time, it is more fun!

Yes, teacher. I like this board game as it can help me. I was allowed to learn new knowledge this time, so I can master it faster.

Sure, teacher. This board game is helping me to learn a lot. For example, I can master… emm….what are renewable and non-renewable energy easily through this board game

Yes…teacher… I prefer…emm…to use this board games…ah-ha… explain the contents, hmm… especially when I try to answer questions. Because it is more fun…to discuss with my… group members… together…and can learn it faster…

Yes, teacher…I do like… to use this board game to…hmm… list the… Science materials…For example, I can understand better about…the… hmm…classification of materials in Chapter 8…

Be honest…emm..I relate the Science materials….emm with this… board games…because it can make me…understand and master… the knowledge in this Science classroom…

Yes…teacher…I feel more motivated…to learn Science topic… once I apply this board games…because it can give me to play…and… learn Science topics together with my friends together… interesting!

Ehmm…yes…it is totally different with those…emm…conventional… teaching method…I think that this board games are more fun…and… we can learn and play together…

(PBBG G27P2)

Yes, teacher! I can understand…ehmm…those contents when I am… trying to apply this computerized board game, especially when it… compared with conventional teaching method before… It is because this board game can give me opportunities to play and learn…emm… with other friends…

Yup…I do like this…ehmm… computerized board game…, as it can help me to figure out those Science materials…because it directly… hmm….give me the clearer picture to master….

Absolutely, teacher…after using this kind of board game…ehmm… I learn a lot about Science topics…ah…in the class…For instance… I can understand better…about the concepts of forming shadow…

Yup, teacher…I like to apply this board game in the classroom…I am also use it and able to…hmm…explain the Science contents…and answer the questions…examples…emm…the reflection of light in… hmm…subtopic 5.1…

Yes…in my opinion, I am quite prefer to use…computerized board games to do some works, such as…hmm…listing out the Science… materials….for instance, I can apply it and learn the similarities and differences between energy…

Yes…through the implementation of…ehmm…this version of board games….I can relate the Science materials better…meanwhile, I also able to understand those concepts with the examples too…

Ah…ha….yes..I feel motivated a lot when I try to learn Science... after using these Computerized Board Games. It is because I have the opportunities to learn together with my group members….then I can master those knowledge better…

Yes…For me, this board game is different from those conventional… ehmm…teaching method…It is because I can differentiate that this game always involves me and other friends to play and learn Science together…hmm…and then it is not happening for conventional…em.. teaching method before…

(CBG G32P1)

Phase Two: Generating Initial Codes

This phase started with the coding process, assisted by systematic data analysis. The codes used were data-driven, and a preview of various codes was provided based on the interview transcripts. Undeniably, these codes were employed to identify and label features of the data, especially when they were potentially relevant to the research question in this research. Following Braun & Clarke's (2006) suggestion, the data content was elaborated descriptively through these codes to stay close to the meanings expressed by the research participants after utilizing PBBG and CBG in the Science classroom.

During this phase, it was realized that some codes mirrored the language and concepts used by the participants during the interview session. For instance, the concepts they were trying to share were about their opinions on learning Science after playing PBBG and CBG. Even though they did not explicitly mention the words "learning motivation," the researcher interpreted it through this phase.

It was essential for the researcher to respect contrary codes and resist any impulse to inhibit other group members, as every group member applying PBBG and CBG could identify one or more codes in this research. The researcher suggested taking more time to re-read interview transcripts, as the codes should be refined and discussed across the whole data set, especially concerning the identified research question.

Here are a few examples of coded transcripts for learning motivation among some participants towards applying PBBG and CBG in the Science classroom, as shown in **Appendix AF**.

Phase Three: Generating Themes

Generating themes was identified as the next phase (Braun & Clarke, 2019), emphasizing that the researcher should actively create these themes and not passively wait for the data to be found. Accordingly, initial codes were generated, and the focus of analysis shifted to sorting codes into relevant themes. In this research, the researcher identified themes around learning motivation among 10-year-old participants in utilizing PBBG and CBG in the Science classroom. To support this, themes or descriptions were created by creating a table of how the individual codes determined in the previous phase of analysis overlap or interact with one another (Braun & Clarke, 2006). These visual representations may help with the organization, as the researcher could relate the main themes and subthemes during the thematic analysis in this research. Some codes with their illustrative data extracts from the research participants are shown in **Appendix AF**.

Phase Four: Reviewing Potential Themes

Two levels of review should be identified: (1) Reviewing the level of the coded data from individual transcripts and (2) Reviewing the entire data set by capturing the meaning across the whole (Braun & Clarke, 2006).

A brief description was written for those overarching themes, focusing on the learning motivation among those research participants in the Science classroom after implementing PBBG and CBG. These descriptions helped the researcher better understand the main message of each theme as they differed from one another during the thematic analysis. Additionally, these descriptions involved illustrative quotes and codes to exemplify those themes. All coded data extracts were reviewed to ensure the representation

of coherent patterns, as it was about the learning motivation among research participants in learning Science after utilizing PBBG and CBG in the Science classroom. This review ensured that the generated themes reflected the whole data set, thus allowing the next phase of analysis to begin as soon as possible. Table 6.30 shows certain codes, and the corresponding themes.

Table 6.30: Codes and the Corresponding Themes

Definition and Labels for Selected Themes
Theme 1: Learning Content
Based on the feedback from the participants during the interview session, it is evident that most of them, irrespective of whether they were in the PBBG or CBG group, could understand the content better while learning through both versions of board games in the classroom compared to previous lessons. The study indicates that using PBBG and CBG was perceived as beneficial for the participants in understanding the learning content of Science topics from the Year 4 syllabus at the National-Type for Chinese Primary School.
Theme 2: Science Materials
Based on the research participants' responses, it is evident that their experiences relating to the Science materials were positive, particularly when they were given the opportunities to use PBBG or CBG in the Science classroom. Implementing both versions of board games allowed them to play and learn Science knowledge and skills with their group members, which enhanced their understanding and ability to better relate to the Science materials.

Table 6.30 continued

Theme 3: Learning Experience

Referring to the learning experience of the research participants, it was evident that many of them used PBBG and CBG with CL in the Science classroom and gained a deeper understanding of the Science topics. As mentioned by selected research participants during the interview session, they successfully mastered the knowledge from Subtopic 5.1, "Light Travels in a Straight Line," Subtopic 7.2 ", Renewable and Non-Renewable Energy," and others. Consequently, they had an exciting and enriching learning experience while implementing PBBG and CBG in the Science classroom.

Theme 4: Personal Feeling

The theme of personal feelings has been linked to the participants' motivation to learn Science after implementing PBBG and CBG with CL in the classroom. The theme indicates that most participants felt motivated to learn Science once they were exposed to the usage of both board games. This motivation encompasses intrinsic and extrinsic factors, as they were allowed to use the board games and learn new knowledge simultaneously, resulting in a better mastery of Science topics.

Theme 5: Perception

The theme of research participants' perceptions emerged during the interview sessions. Evidently, they believed both board games could aid them in understanding the Science materials better. Moreover, they perceived that the implementation of PBBG and CBG differed significantly from CT previously used by their teachers. As a result, they expressed openness to applying PBBG and CBG in the Science classroom, indicating a positive reception to innovative teaching approaches.

Table 6.30 continued

Theme 6: Application The research participants responded positively to applying PBBG or CBG with CL in the Science classroom. They expressed their ability to use board games effectively to explain the contents and answer questions. By successfully applying these board games, they could learn the selected Science topics with their group members, leading to a clear understanding of the learning contents by the end of the lesson. This positive experience made them open to accepting and embracing these versions of board games as enjoyable and effective tools for learning Science in the classroom.
Theme 7: Classification The research participants responded positively to applying PBBG or CBG with CL in the Science classroom. They expressed their ability to use board games effectively to explain the contents and answer questions. By successfully applying these board games, they could learn the selected Science topics with their group members, leading to a clear understanding of the learning contents by the end of the lesson. This positive experience made them open to accepting and embracing these versions of board games as enjoyable and effective tools for learning Science in the classroom.

Phase Five: Defining and Naming Theme

For this phase, it was recommended by Braun and Clarke (2013) that the names for themes should be "catchy" so that the essence of the analysis was captured properly. Thus, the theme name sometimes could come from a direct quote, the identification of an analytic take on, and the focus of the data set. In this research, it was better to involve the

aspect of learning motivation from those research participants, as the essence of this process was captured and stayed close to the data set. Hence, the researcher went back and forth between the data from the interview transcripts, as those themes have been determined to ensure the story was organized into a "coherent and internally consistent account."

A detailed analysis was constructed beyond that of just a description or paraphrase of the data for each of the identified themes in this research. Most importantly, the researcher ensured that an identification of the story of each of the themes as well as how this story and theme fits the broader story of the data set based on the research question, which was relevant to the learning motivation among the research participants after utilizing both PBBG and CBG in Chapter 1, respectively. A few excerpts were provided as follows:-

Theme 1: Learning Content

Regarding this theme, the research participants have provided their perceptions toward implementing PBBG and CBG, respectively, compared with the previous lesson. Hence, one of the PBBG participants, PBBG G50P1 highlighted this.

Okay. So, I wanna know that… do you understand the content when you learn through Paper-Based Board Games in classroom… emm… compared with the previous lesson? Tell me why (Researcher)

After…ehmm…I was exposed to…Paper-Based Board Game, as it… hmm…compared to previous lessons…I think I can understand the… ah..content easily… (PBBG G50P1).

Furthermore, his comments were supported by another participant, PBBG G40P3, as her opinion of *PBBG G40P3* was similar to the previous comments.

In my opinion, I think with this board game…ehmm…I can know… ah…more about the learning content in Science topics…as compared with the previous lesson…Hence, it is quite interesting for me to do so…

On the other hand, this research also focuses on implementing CBG with CL, as CBG G44P4 and *CBG G16P3* commented.

For me, I think that I can understand…hmm…the learning content of Science….after applying the computerized board game…especially if compared with the previous lesson…because it always involves the...em… me and other group members to play and learn Science together… (CBG G44P4)

Emm….I can say that I do understand…hmm…the Science contents while I am applying this board game…if compared with previous… lesson…It is because for previous lesson, what I was doing only… emm….listen to teacher's instruction and never play and learn with my friends like this before… CBG G16P3

It has been concluded that both PBBG and CBG groups have agreed, as they understand the content and are given the opportunities to learn through those board games in the classroom compared with previous lessons. It is because they would have two-way communication during the implementation of PBBG and CBG, instead of emphasising teachers' instruction in those previous lessons.

Theme 2: Science Materials

Referring to the second theme, Science materials, it is realized that most participants have similar perceptions toward implementing PBBG and CBG, respectively, as they can relate to the Science materials in the Science classroom, as mentioned by *PBBG G27P2.*

I see. So, do you relate the Science materials to using Paper-Based Board Games? Why? (Researcher)

Be honest…emm...I relate the Science materials….emm with this board games…because it can make me…understand and master the knowledge in this Science classroom… (PBBG G27P2)

Another participant, PBBG G50P1, shared the perception that with the usage of PBBG in the classroom, he could master the concepts of natural and man-made materials from Chapter 8.

Positively, teacher…I can relate this board game…ehmm…with the Science materials…hmm….in the classroom…For instance, I can… emm…to understand the concept of natural and man-made materials (PBBG G50P1)

On the other hand, a participant from CBG groups, CBG G23P2, for instance, has mentioned that her ability to relate to Science materials was enhanced due to the application of CBG in the Science classroom.

Researcher: So, do you…hmm…relate the Science materials…with the usage of… Computerized Board Games? Why?

Hmm…. through this board game, I am able to relate Science material in the classroom…It is because I have clearer picture to master those knowledge with my friends…. (CBG G23P2)

Another study participant, CBG G51P1, supported it, as he could relate the Science materials after implementing CBG with other group members.

Yup...for me…I can relate the Science materials…with the help of computerized board game in the classroom…it is because… I can play and learn with my other group members…so we can…mm…ya…master those knowledge better way… (CBG G51P1)

Overall, it can be summarized that both groups applying PBBG and CBG have the same opinions, as they can relate to the Science materials after exposure to those versions of board games.

Theme 3: Learning Experience

It focuses on the learning experience among the research participants from both PBBG and CBG groups. PBBG G27P2, for instance, has commented that he learned a lot after utilizing PBBG in the classroom, particularly for the concepts of renewable and non-renewable energy.

Then, do you learn a lot…emm…after using these...Paper-Based Board Games in the classroom? Hmm… and please give examples…

Sure, teacher….This board games is really helping me out to learn… a lot. For example…I can master… emm….what are renewable energy and non-renewable energy easily…through these board games… (PBBG G27P2)

Another PPBG participant, PBBG G33P1, also mentioned that she learned much from the selected Science topics, especially the types of energy, after using PBBG with collaboration in the classroom.

In my opinion, ehmm….I think I have learnt a lot…after using this… hmm….board game in the classroom…I can easily learn about the types of energy while playing it with my friends… (PBBG G33P1)

The researcher also focuses on the CBG group as one of the research participants, CBG G51P1.

As I know…yup…after using this computerized board game…I am… really learn a lot…example…is I have gained the knowledge about refraction of light and light can travel in a straight line… (CBG G51P1)

CBG G32P1 also supported the statement that has successfully learned a lot about Science topics, such as the concepts of forming shadow in Chapter 5 after implementing CBG with CL.

Absolutely, teacher…after using this kind of board game…ehmm… I learn a lot about Science topics…ah…in the class…For instance… I can understand better…about the concepts of forming shadow… (CBG G32P1)

It is said that most of the participants, regardless of the groups applying PBBG or CBG, have learnt a lot during the activity in the Science classroom, as this scenario allows them to master the new knowledge from those selected topics better.

Theme 4: Personal Feeling

The personal feeling theme has been identified based on the motivation among the research participants from both PBBG and CBG groups in the classroom. PBBG G40P3 commented that she felt motivated to learn Science topics while playing it with her group members.

Hence, emm...do you feel motivated to learn Science after these board games? Tell me why (Researcher)

Of course, teacher…In my opinion…I feel motivated to learn Science while I am playing this board game…with my friends…because I can discuss and play with them, at the same time…also learn new knowledge (PBBG G40P3)

Another PBBG participant, PBBG G33P1, also mentioned feeling motivated after implementing the board game with her friends during the Science lesson. It is because she was given many opportunities to play and learn with other group members, as this scenario allowed her to learn new knowledge more easily.

During the application of this board game, I always…emm….feel motivated…to learn the Science topics…It is because this board game gives me more chances to play and learn with my friends… (PBBG G33P1)

One of the CBG participants, CBG G51P1, agreed that she felt motivated to learn Science after exposure to the implementation of CBG with CL with others.

Absolutely…I am really feel motivated in learning Science…after this ah….computerised board game…because…what is important for me is I can learn and work collaboratively with my friends…it is much easier for me to memorize those scientific facts… (CBG G51P1)

CBG G16P3 also felt motivated to learn more about Science topics after conducting CBG with her friends in the classroom, as it encourages her to play and learn with other group members simultaneously.

For me, yes…I feel motivated…ehmm…to learn more knowledge… hmm…about Science after playing this board game with my friends… It is because this board game encourages me to play and learn with… hmm…my group members…so that…we can master those skills… better… (CBG G16P3)

Overall, it can be assumed that both PBBG and CBG groups have the same perceptions, as they feel motivated after exposure to both versions of board games in the Science classroom. It is because they are allowed to play and learn with their friends, as this situation has created an exciting learning environment for them to understand and master the knowledge better.

Theme 5: Perception

PBBG G40P3 has opined that she preferred to apply Paper-Based Board Games with others, as it allows her to figure out the Science materials during the interview session.

Okay. Then, do you like Paper-Based Board Games to help you figure out the Science material? Why? (Researcher)

Yes. Through this board game too…hmm…I also would like to say that it can help me to figure out those Science materials because it makes me feel fun and excited to learn it more (PBBG G40P3)

During the interview session, another study participant from PBBG groups, PBBG G10P3, commented that she likes to use Paper-Based Board Games, particularly when she was encouraged to figure out what the Science materials are about in the classroom.

Yes, teacher…I do like this board game…one of the reasons is to figure out what the Science material is because it is so much fun to apply it while learning Science at the same time (PBBG G10P3)

CBG G23P2 has mentioned that she likes to use CBG with CL, as it can help her to figure out those Science materials during the interview with the researcher.

Yup, I like to apply this computerized board game…. to figure out those Science materials….For instance, what I can do is learn the types of materials in Chapter 8 through this board game… hmm…so that I can easily master the learning contents (CBG G23P2)

Another CBG participant, CBG G16P3, also preferred to use CBG with CL. as she was able to figure out the Science materials while playing CBG with other group members.

Yup…for me, I like to play this computerized board game…so that… it can assist me to…ehmm…figure out those Science materials…it is because this board game can allow me to learn more about Science contents, such as…emm…reflection of light and types of materials (CBG G16P3)

Overall, it can be concluded that most of the participants, regardless of PBBG or CBG groups, have shared similar opinions, as they prefer to use board games to assist them in figuring out those Science materials better and easier.

This theme also focuses on the perception of PBBG and CBG participants, particularly their similarities and differences during the interview session. PBBG G10P3, for instance, has commented that PBBG differs from CT.

Are Paper-Based Board Games different from this conventional teaching method? Why? (Researcher)

Yup, teacher…In my opinion, this kind of board game is different with conventional teaching method in the classroom because I feel like participated more in learning Science through this board game (PBBG G10P3)

Another PBBG participant, PBBG G50P1 ,also thought PBBG were different from CT during the interview.

In my opinion…absolutely, these board games are different from conventional teaching methods in Science class. It is because we can have two-way communication with each other (PBBG G50P1)

CBG G44P4 has commented on the usage of CBG with CL, as it was different from the CT that has been applied by their teachers frequently in the Science classroom.

In my opinion, yes, this kind of board game is different from the conventional teaching method…it is because this teaching method… hmm…gives me lots of chances to play and learn with my friends (CBG G44P4)

CBG 32P1 has opined that the application of CBG differs from the CT in the Science classroom.

Yes…For me, this board game is different from those conventional… ehmm…teaching method…Because I can differentiate, this game always involves me and other friends

playing and learning Science together…hmm…and then it is not happening for conventional…em.. teaching methods before (CBG G32P1)

Overall, they all expressed that both PBBG and CBG differ from CT during the interview session. Implementing CBG allows them to play and learn Science knowledge as a team compared to the CT, as it only involves one-way communication between teachers and themselves.

Theme 6: Application

PBBG G40P3 has commented that she preferred to use PBBG to explain Science contents and answer the questions during the interview session.

So, in your opinion, do you like to use Paper-Based Board Games and then explain the contents or emm…answer the questions? Tell me more about it (Researcher).

Definitely, I like to apply this version of the board games I can explain the learning contents in the Science textbook… then I also can answer the questions after playing this board game (PBBG G40P3)

PBBG G33P1 also shared her comments during the interview, expressing her preference for using PBBG in the classroom. She mentioned that she enjoys using PBBG because it allows her to explain the Science content and answer questions effectively.

Yes, I do like to use Paper-Based Board Games in the classroom as I can…ehmm…explain the content that I learnt and…hmm…able to… answer the questions… Meanwhile, I also can play and learn through this board game. (PBBG G33P1)

CBG G51P1 expressed her satisfaction with utilizing board games as an effective tool for educating and addressing queries related to the subject matter.

Hmm...I think I like to apply this board game which is a computerized board game especially try to explain the Science contents. At the same time, I also able to answer the questions…for this case, what I have learnt is using this board game to understand more about the… hmm…concepts of energy and so forth… (CBG G51P1)

Participant CBG G16P3 preferred to apply CBG with CL in the Science classroom, as it provided her with the opportunity and encouragement to explain the learning contents and answer questions during its implementation.

Yes. In my opinion, I like to apply this kind of board game, which is a computerized board game. So that I can explain the contents and answer the questions, under this condition, I am also able to…ehmm... then I can understand it better and apply in daily life (CBG G16P3)

In conclusion, the PBBG and CBG group participants expressed similar preferences, as they enjoyed engaging with both versions of the board games. They found them effective in explaining the learning contents from the Science syllabus and answering questions during their activities.

Theme 7: Classification

PBBG G10P3 has mentioned that she likes to use PBBG and list out the Science materials during the group activity in the classroom.

By the way, do you like to use this Paper-Based Board Game to list their Science materials? Can you share it with me?

I like to…use Paper-Based Board Games to list Science materials. Em... for this case, I can hmm…play it and learn the examples of energy in Chapter 7, which are renewable and non-renewable energy (PBBG G10P3)

Another PBBG participant, PBBG G27P2, shared her willingness to use PBBG in listing their Science materials were positive, as she listed the Science materials during the group activity in the classroom. Another participant, CBG G44P4, likes to use CBG with CL to list Science materials in the classroom.

Yes, teacher. I do like to use this board game to…hmm… list the Science materials…For example, I can understand better about…the…hmm…classification of materials in Chapter 8. (PBBG G27P2)

Yup. I like to use or apply computerized board game. So, I am able to list Science materials. For example, with the help of this board game, then I can understand the similarities and differences of energy better (CBG G44P4)

Additionally, CBG G32P1 stated that she preferred to apply CBG to list Science materials, particularly learning the similarities and differences between energy on the Earth.

Yes. In my opinion, I prefer to use computerized board games to do some work, such as…hmm…listing out the Science materials. For instance, I can apply it and learn the similarities and differences between energy (CBG G32P1)

Overall, the feedback from all the invited participants was consistently positive, with each expressing a preference for using both versions of the board game to list the Science materials.

Phase Six: Producing the Report

The narrative presented in this section goes beyond mere data description and aims to build a compelling argument to address the research question effectively. To achieve this, the researcher conducted a final review to ensure a common understanding of the data set in the study. The report includes direct quotes from the interview transcripts, crucial to the research question about learning motivation among the participants when using PBBG and CBG in the Science classroom.

During the interviews, it was evident that most respondents better understood the learning content when using PBBG and CBG than traditional teaching methods. They expressed that both versions of board games helped them connect with the Science materials and facilitated a more engaging learning experience. The exposure to PBBG and CBG in the classroom was considered new and exciting for the participants, and they felt motivated to learn Science as a result. They found these teaching methods enjoyable and collaborative, fostering a sense of teamwork and enthusiasm for learning together in the classroom.

The participants' positive experiences with PBBG and CBG led them to prefer these methods over CT approaches like PowerPoint presentations. They liked to use PBBG and CBG to explain what they had learned and to answer questions that they believed would improve their performance. Additionally, using PBBG and CBG in collaboration with friends helped them better understand and master the Science materials.

The interview data depict enhanced learning motivation and engagement among the participants when utilizing PBBG and CBG in the Science classroom. These findings

highlight the potential benefits of incorporating game-based approaches to promote a more enjoyable and effective learning environment for young learners.

Referring to the interview transcripts and the subsequent thematic analysis, there was no sign of significant discrepancies or variations in the feedback provided by participants regarding their learning motivation after implementing PBBG and CBG in the Science classroom. The themes extracted from the interviews indicate consistent positive perceptions and experiences across both groups. Participants expressed that they could understand Science content more easily through the use of both PBBG and CBG compared to traditional teaching methods. They appreciated the interactive nature of the games, which allowed for two-way communication and collaboration among peers. Participants reported that they could relate to Science materials better after engaging with both versions of board games. They found that the games facilitated a clearer understanding of concepts and allowed for more active participation in learning. Feedback from participants highlighted that they learned a lot from the activities in the Science classroom. They appreciated the opportunities to engage with the material in a hands-on and collaborative manner, leading to a more enriching learning experience. Participants expressed feeling motivated to learn Science topics after using both PBBG and CBG. They enjoyed the interactive and engaging nature of the games, which encouraged active participation and discussion among peers. Participants perceived PBBG and CBG as different from conventional teaching methods. They appreciated the opportunity for collaborative learning and found the games to be more engaging and interactive compared to traditional approaches. Meanwhile, participants expressed a preference for using both versions of board games to explain Science content and answer questions. They found the games effective tools for learning and enjoyed the opportunity to engage with the material in a

hands-on manner. Also, the participants expressed a preference for using both versions of board games to list Science materials. They found the activities helpful in reinforcing their understanding of the material and appreciated the opportunity for collaborative learning. Overall, the feedback provided by participants during the interviews indicates consistent positive perceptions and experiences with both PBBG and CBG in the Science classroom. The thematic analysis reveals a shared enthusiasm for the interactive and collaborative nature of the games, as well as their effectiveness in facilitating learning and engagement among students.

Hence, the research highlights the importance of addressing low motivation among students, which could be a significant barrier to effective science learning and contribute to the decline in international rankings. By demonstrating that PBBG and CBG, with CL, have a higher impact on learning motivation compared to traditional teaching methods like PowerPoint presentations, the study suggests that integrating more engaging and interactive learning approaches can help improve students' motivation and, consequently, their academic performance in science.

The findings underscore the role of learning motivation in overcoming educational challenges such as misconceptions and lack of understanding in science subjects. By showing that PBBG and CBG, with CL, are more effective in promoting learning motivation compared to CT, the research suggests that enhancing motivation through interactive and collaborative learning experiences can help address these issues and improve students' overall performance in science assessments.

The research also highlights the potential of PBBG and CBG, with CL, to address the scarcity of interactive and collaborative learning resources tailored for science education in National-Type Chinese primary schools. By demonstrating the effectiveness

of these approaches in promoting learning motivation among 10-year-old participants, the research provides valuable insights into how such resources can be integrated into science curricula to enhance student engagement and achievement.

The results affirm the potential of PBBG and CBG, with CL, to address the shortcomings of traditional teaching methods by providing hands-on, interactive, and collaborative learning experiences that enhance learning motivation. By highlighting the higher effectiveness of PBBG and CBG compared to CT in promoting motivation, the study underscores the importance of incorporating innovative and engaging learning approaches into science education to improve student outcomes.

Therefore, the findings validate the relevance of the problem statements by demonstrating how different learning approaches impact participants' learning motivation and, consequently, their academic performance in science. By providing evidence of the effectiveness of PBBG and CBG, with CL, in promoting motivation, the research supports the importance of addressing this aspect in efforts to enhance science learning outcomes among primary school students.

6.4 Summary

This chapter conducted a thorough data analysis of the collected data, encompassing the calculation for gender differences between CT, PBBG, and CBG with CL, the change scores from the pre-test to the post-test and mean scores of social interaction and learning motivation. Multiple methods, including pre-test and post-test, questionnaires, classroom observation, and interviews, were employed to compare the effects of the CT, PBBG, and CBG with CL on 10-year-old participants' Science learning.

The analysis indicated that gender does not significantly influence the change scores from pre-test to post-test, as well as the mean scores of social interaction and learning motivation achieved through CT, PBBG and CBG in this research. It also revealed significant differences among the groups applying the three teaching methods. Specifically, the PBBG group demonstrated superior learning performance compared to the CT and CBG groups. This finding indicates that PBBG was more effective in facilitating learning outcomes in the Science classroom than the other two methods.

A comprehensive evaluation of CT, PBBG, and CBG's effectiveness in promoting CL in Science education was achieved by incorporating various data collection methods. These findings carry important implications for educators and researchers interested in using board games to enhance learning experiences, particularly in Science education for young learners.

In conclusion, this chapter presents a detailed data analysis and highlights the significant advantages of using PBBG over CT and CBG in CL, leading to improved learning outcomes for 10-year-old participants in the research.

CHAPTER 7

DISCUSSIONS

7.1 Introduction

The research objectives were to determine the gender differences, the change scores from pre-test to post-test, and the mean scores of social interaction and learning motivation achieved through CT, PBBG and CBG on 10-year-old participants in Science classrooms. Based on the findings from the previous chapter, this chapter focused on a comprehensive discussion of the findings, supported by relevant literature. The discussion was organized into four subsections aligned with the research questions mentioned in Chapter 1. This section aims to provide a thorough analysis and interpretation of the findings obtained in the research. Based on previous research studies and pertinent literature, it offered detailed explanations and support for the observed outcomes.

7.2 Gender Differences between CT, PBBG and CBG in Learning Science among 10-year-old Participants

This research revealed that gender does not significantly influence the change scores from pre-test to post-test, as well as the social interaction and learning motivation scores achieved through CT, PBBG and CBG among the 10-year-old participants in Science classrooms.

Furthermore, the findings of Shawaqfeh et al. (2020) support the results of this result. In this study involving 309 pharmacy students, the research focused on various aspects such as preparedness, attitude, barriers, and areas of development. The results

showed no significant gender differences. Live demonstration sessions, pre-recorded videos, and PowerPoint presentations did not result in varying outcomes based on gender.

Also, the finding of this research was consistent with Namaziandost and Cakmak (2020), as this study examined the impact of flipped classrooms compared to traditional teaching methods on 58 intermediate EFL learners. For the traditional teaching group, materials included lecture notes, videos, and PowerPoint slides. The research found no gender differences in learning outcomes when using traditional teaching methods.

The study of Chiquito et al. (2020) further supports this research, as involving 98 engineering students, male and female students attended lectures where teachers used PowerPoint slides to explain lessons and solve problems. After exams, there were no significant differences in the performance of male and female students, suggesting that gender did not influence learning outcomes.

Ja'ashan (2020) also supported these findings, as 261 EFL students and 36 teaching staff engaged in e-learning activities, utilizing materials such as PowerPoint slides, PDFs, course notes, and feedback materials. The results showed no significant gender differences in students' participation and performance in e-learning activities.

The findings aligned with the findings of Wynter et al. (2019), as it aims to explore attitudes among medical students towards traditional learning methods and found no gender differences. The research aimed to ensure no inadvertent gender bias in medical education.

In view of PBBG, the findings of this research were similar to the study of Lin & Hou (2016), as it focused on integrating role-play and peer learning through a physical board game with 57 junior high school students in Taiwan. The findings revealed no

significant gender-based differences in flow and learning effectiveness, suggesting that this educational game was suitable for both male and female students.

Additionally, this research aligned with the study conducted by Al-Tarawneh (2016), as it investigated the use of educational board games to teach scientific concepts to first-grade students. The research included 53 male and female students and revealed no statistically significant gender-based differences in students' scientific concepts acquisition or the interaction between teaching methods and gender.

The study by Ogunsile & Ogundele (2016) further supports this research, as a board game focused on nutrition education was used to improve the knowledge, attitude, and practice of healthy eating among 143 secondary school students. The findings showed no significant main or interaction effect of gender and geographical location on knowledge and practice.

For CBG, Li (2015) support the findings of this research by developing a digital game for knowledge acquisition and retention of road rules among 42 participants in Alberta, Canada. The results indicated no statistically significant gender differences in participants' knowledge gain regarding road rules and road safety.

Similarly, Dorji et al. (2015) investigated gender differences in 129 students in eastern Bhutan participating in a residence energy-saving game-based inquiry. The findings showed that different learning approaches had no significant impact on learning achievements and awareness based on gender. Both male and female students gained similar levels of knowledge irrespective of the learning approach.

7.3 Differences in Pre-test and Post-test Scores between CT, PBBG and CBG in Learning Science among 10-year-old Participants

The fourth research objective investigated the differences in pre-test and post-test scores between CT, PBBG and CBG, with CL for 10-year-old participants in the Science classroom. Based on the findings in Chapter 5, conclusions can be drawn regarding this objective. The findings highlight the change scores of the selected Science topics, including "Properties of Light", "Energy", and "Materials" following the administration of pre-test and post-test.

The analysis revealed that the PBBG group showed a higher mean score and lower standard deviation, suggesting greater effectiveness in academic performance among participants compared to the CT group and CBG group. Overall, these findings hold great relevance and significance for researchers exploring the efficacy of various board game approaches in improving academic performance within educational environments.

The observed differences in academic performance among the PBBG, CBG, and CT groups can be attributed to several key distinct teaching approaches employed in each group. The PBBG group likely experienced a more interactive and engaging learning environment compared to the CT group. Paper-Based Board Games offer hands-on learning experiences that encourage active participation, collaboration among peers, and problem-solving skills development. This interactive approach can lead to increased motivation and retention of information, resulting in higher academic performance. Similarly, the CBG group may have benefited from a visual and interactive learning experience provided by the board games. These games often incorporate multimedia elements, animations, and interactive simulations that can enhance understanding and engagement with the material. The immersive nature of CBG can stimulate curiosity and

exploration, leading to improved academic performance compared to traditional teaching methods. In contrast, the CT group may have experienced a more passive learning environment characterized by lectures, presentations, and rote memorization. Traditional teaching methods often focus on one-way communication from the teacher to the students, limiting opportunities for active participation and engagement. This passive approach may result in lower levels of motivation and understanding among students, leading to decreased academic performance compared to the PBBG and CBG groups. Another factor contributing to the observed differences in academic performance could be the variability in instructional methods used in each group. While the PBBG and CBG groups likely experienced innovative and interactive teaching approaches, the CT group may have relied more heavily on traditional instructional methods, which may not cater to the diverse learning needs and preferences of pupils. The PBBG and CBG groups may have benefitted from active learning strategies inherent in board game-based approaches. Active learning encourages students to engage with the material, apply critical thinking skills, and collaborate with peers. By actively participating in the learning process, students in the PBBG and CBG groups may have achieved deeper levels of understanding and retention of information, leading to higher academic performance compared to the CT group. Overall, the observed differences in academic performance among the PBBG, CBG, and CT groups can be attributed to the unique teaching approaches employed in each group. While the PBBG and CBG groups likely experienced interactive and engaging learning environments that fostered active participation and collaboration, the CT group may have experienced a more passive learning environment characterized by traditional teaching methods. These findings underscore the importance of exploring innovative teaching approaches, such as

board game-based learning, to enhance academic performance within educational environments.

By incorporating AT and SCT into the discussion, we can better understand how the interactive and collaborative learning environments fostered by PBBG and CBG contribute to higher academic performance compared to traditional teaching methods. These theoretical frameworks highlight the importance of social interaction, collaboration, and active engagement in the learning process, all of which are facilitated by board game-based approaches like PBBG and CBG. Overall, the findings underscore the significance of exploring innovative teaching approaches that leverage social interaction and collaboration to enhance academic performance in educational settings.

The findings aligned with the findings of Parks' (2023) study, which explored the use of "Aerobic Respiration: The Board Game" in biology class with undergraduate students. Park's study demonstrated significantly favourable perceptions of board games as their learning tool, enhancing motivation to learn cellular respiration pathways in the classroom.

Similarly, Alejandria et al. (2023) reported positive outcomes when using chemistry board games as supplemental tools for learning the periodic table of elements with senior high school students. The post-test test mean scores showed a significant difference between the control group (traditional teaching method) and experimental group (board game), indicating the effectiveness of the chemistry board game in enhancing understanding of the periodic table of elements.

Moreover, the findings of Miculob et al. (2022) support the result of this research. Their study involved using the ATP Quest board game with 215 students from La Salle

University-Night Hugh School (LSU-NHS). The study demonstrated score improvements in the summative exam for the three learner types. Additionally, Soewono et al. (2022) further supports this research. Their research focused on the online and electronic board game "ATtack Covid Game", which aligns with the concept of CBG in this research. 11 High school students were involved as participants, and their findings indicated that "ATtack Covid Game" was widely enjoyed. This research also mentioned plans for developing and distributing an electronic version of the board game to schools within the Dian Harapan School group.

Moreover, Aliyu et al. (2021) support the findings of this research through their development of the Symperiod Board Game, which aimed to assess the understanding of chemical symbols and periodicity of elements among 20 Form IV students. This parallels implementing PBBG and CBG with CL for 10-year-old participants in a Science classroom. The findings indicated that group members demonstrated excellent cognition in learning periodicity using the Symperiod board game, as evidenced by the significant improvement between pre-test and post-test scores.

Additionally, this research aligned with the study conducted by Deta et al. (2021), where a physical, educational board game was provided to teach physics. The findings revealed that certain educational physics games did not improve student learning outcomes. Conversely, this research demonstrated that learning media based on educational board games and cards is highly effective in enhancing student learning outcomes compared to CBG and CT in the Science classroom.

Also, the finding of this research was consistent with Tsai et al. (2021), who developed the "Be Blessed Taiwan" Board Game to teach high school students about sustainable development, particularly biological conservation. The findings indicated a

significant increase in test scores after implementing the board games, demonstrating a large effect on biodiversity concepts and a medium effect on biological conservation concepts.

The study by Wang et al. (2019) further supports this research, as a collaborative board game was created to enhance the teaching and learning of organic chemical compounds among high school students. The findings reveal significantly greater improvement among students engaged in the gamified learning activity than those in the lecture-based teaching model. This mirrors the research's results, highlighting the effectiveness of applying PBBG and CBG compared to CT (PowerPoint Presentation). Additionally, the study by Fauziah et al. (2018) developed the Monopoly Game (MLG) to promote qualified scores for student competencies, especially in thermal energy topics. The findings indicated that the board game improved student competencies, as measured through rubrics and paper and pencil tests.

Wu et al. (2018) conducted similar research, providing an educational board game to enhance learning about organic chemical structure and functional groups compared to a lecture-based teaching approach. The findings indicated that the CSLS model teaching activity promoted students' understanding of organic chemical structure and functional groups more effectively than the traditional lecture-based teaching model. This aligned with this research's comparative analysis of applying PBBG and CBG with CT.

Furthermore, this research was consistent with the study conducted by Zheng et al. (2018), who developed the 3D electronic board game "Organic Savior Game" to enhance elementary students' understanding of human internal organs. Similar to this research, they administered pre-tests and post-tests and found that implementing the board game has significantly improved learning achievements for human internal organs and health

information compared to conventional board games. In this research, the application of PBBG distributed better performance compared to CBG and CT in the Science classroom.

Board games have proven effective beyond Science education, as demonstrated by Cutumisu et al. (2019), who found that learning neonatal resuscitation through the physical version of board games increased participants' knowledge and performance in specific resuscitation situations. Similarly, in this research, implementing PBBG enhanced learning motivation among 10-year-old participants more effectively than CBG and CT.

Viggiano et al. (2018) conducted research similar to this, observing nutritional knowledge and eating behaviour in Italian children and adolescents exposed to a board game for six months. The results showed that the board game improved the participants' nutritional knowledge, as evidenced by the pre-test and post-test results. Similar findings were reported by Dancz et al. (2017), where American undergraduate students who created or modified the board game to teach engineering concepts to their peers performed better than those who took the traditional assessment test.

Azizan et al. (2018) also supported these findings, revealing that college engineering students in Malaysia exposed to board games showed greater communication skills and performed better in the course than students who took the same course the previous year. Moreover, (Dziob, 2020) conducted a study using physical board games to assess the knowledge of Polish students in a physics course. The results indicated that playing the board game increased knowledge, as students from the experimental group performed better than the control group in the post-test.

The application of board games extends beyond Science and can be involved in finance, as (Bayeck, 2020) demonstrated. Campbell (2016) further exemplified this by

showing that playing the Monopoly board game can be an effective alternative for students to gain a practical and conceptual understanding of real options for capital budgeting in the finance field. The findings showed a statistical difference between the scores of physical board game players on the real option part of the final exam and non-gaming students who took the same exam the previous year, indicating that those who played the board game scored higher than in a conventional class.

The application of board games extended to various educational contexts. Nieh and Wu (2018) conducted a study using a board game to teach bullying among fifth graders in Taiwan. The board game aimed to change attitudes towards bullying and enhance knowledge. Participants were randomly divided into three groups: a game-only group, a game-with-debriefing group, and a control group. The post-test significantly changed participants' bullying knowledge in both gaming groups. Particularly, the game-with-debriefing group demonstrated greater empathy and reduced bullying attitudes.

In the field of language learning, Lodzikowski and Jekiel (2019) developed a physical board game on English prosody for university students learning English as a foreign language in Poland. Implementing the board game led to a moderate increase in students' performance on post-game class exams compared to those in traditional classes. Wu et al. (2014) conducted a study exploring language learning through board gameplay among high school students in Taiwan. Participants were randomly assigned to a board game, a digital board game, and a traditional instruction group. The findings differed from this research, as students in the digital board game outperformed those in the traditional instruction and board game groups. The digital board game was considered more conducive to language learning in the classroom.

7.4 Differences in Social Interaction between CT, PBBG and CBG in Learning Science among 10-year-old Participants

The questionnaire administered in this research revealed significant differences in social interaction among CT, PBBG and CBG participants, with CL for the features among the 10-year-old participants in a Science classroom. This research shows notable disparities in change scores among the CT, PBBG, and CBG groups. To be precise, the CT group exhibits a substantial variance from the CBG group, and the PBBG group displays a noteworthy distinction from the CBG group. Nevertheless, no statistically significant difference between the CT and PBBG groups is observed. These findings underscored the positive impact of PBBG on social interaction within the Science classroom. The high mean scores suggested incorporating PBBG into the learning process fostered active participant engagement and collaboration rather than CT and CBG. The results affirmed the efficacy of PBBG in creating an enriching learning environment that facilitates effective social interaction among 10-year-old participants. Participants in the PBBG group likely experienced higher levels of social interaction due to the nature of board game-based learning. PBBG encourage active participation, collaboration, and communications among players, as they work together to solve problems, strategizes, and achieve common goals. The interactive and hands-on nature of PBBG fosters a supportive learning environment where students engage with each other, share ideas, and collaborate on tasks, leading to effective social interaction.

Similarly, participants in the CBG group may have experienced meaningful social interaction facilitated by computerized board games. CBG often incorporates features such as multiplayer modes, online forums, and interactive elements that promote engagement and interaction among players. Through online platforms and digital interfaces, CBG

participants can communicate, collaborate, and compete with each other, fostering social interaction and peer learning. In contrast, participants in the CT group may have experienced limited social interaction compared to the PBBG and CBG groups. Traditional teaching methods often involve one-way communication from the teacher to the students, with limited opportunities for active participation and peer interaction. Classroom lectures, presentations, and rote memorization activities may not promote meaningful social interaction among students, leading to less engagement and collaboration compared to board game-based approaches.

The collaborative and competitive elements inherent in both PBBG and CBG encourage teamwork, cooperation, and healthy competition among participants. By working together towards common goals, solving challenges, and sharing resources, PBBG and CBG participants develop essential social skills such as communication, negotiation, and conflict resolution. These collaborative experiences contribute to the formation of positive peer relationships and foster a sense of belonging within the learning community. The supportive and inclusive learning environments created by PBBG and CBG promote social interaction by providing opportunities for students to express themselves, share perspectives, and learn from each other. By encouraging active participation and valuing diverse contributions, PBBG and CBG foster a sense of community and belonging among participants, leading to enhanced social interaction and peer relationships.

Overall, the observed differences in social interaction among participants in the CT, PBBG, and CBG groups can be attributed to the unique teaching approaches employed in each group. While PBBG and CBG foster active participation, collaboration, and peer interaction, CT may provide fewer opportunities for meaningful social interaction. These findings underscore the importance of incorporating interactive and collaborative learning

activities, such as board game-based approaches, to promote effective social interaction and peer learning among pupils.

According to AT, learning is situated within social and cultural contexts, and it emphasizes the role of social interaction in knowledge construction. In the case of PBBG, the interactive and collaborative nature of board game-based learning promotes active participation, communication, and collaboration among players. This aligns with AT's emphasis on the importance of social interaction in the learning process. By engaging in collaborative problem-solving and strategizing, PBBG participants create a supportive learning environment where they can share ideas and work together towards common goals. This fosters effective social interaction and peer learning, contributing to a dynamic learning community. In contrast, SCT emphasizes the role of social interaction in knowledge construction and highlights the importance of cooperative learning environments. Both PBBG and CBG promote cooperative and competitive elements that encourage teamwork, cooperation, and healthy competition among participants. Through collaborative problem-solving and shared decision-making, PBBG and CBG participants develop essential social skills such as communication and negotiation. This supports Social Constructivism's notion that learning is a social process that occurs through interaction with others.

Assapun and Thummaphan (2023) conducted a similar study, focusing on board game-based learning for lower secondary school students in Bangkok to enhance problem-solving competency in STEM education. Their findings indicated that problem-solving behaviour and skills scores increased after participating in game-based learning, with a high level of social interaction compared to traditional teaching methods, as was consistent with the findings of this research.

Murray et al. (2022) highlighted the value of using games for educational purposes, emphasising the active agency and interaction among participants. Their study used the "Diamond: The Game" Board Game with secondary school students aged 11 to 18. Similarly, Cardinot and Fairfield (2022) explored the integration of a novel astronomy board game in physics education among post-primary students in Ireland. Their findings aligned with this research, suggesting that game-based approaches can promote active participation and interaction while achieving learning objectives.

Botes (2022) conducted a study with final-year natural Science pre-service teachers involving educational Science board games. Their findings demonstrated the impact of their engagement in the development of educational Science board games on their personal skill development of educational Science board games on their personal skill development related to teaching natural Science.

Additionally, Parekh et al. (2021) implemented educational board games among Hispanic and Caucasian boys aged 13 to 17. Through field notes, video and audio recordings and class observations, their study showed that designing board games in authentic contexts has successfully engaged youth in building models and system thinking, fostering positive social interaction, similar to the findings of this research.

The findings of this research were supported by Pinhatti et al. (2019), who implemented a physical board game as a new and enjoyable learning approach in diagnostic imaging classes. The participants' responses to the post-game questionnaire indicated growth in class engagement, enhancement of the learning process and improved social interaction. Triboni and Weber (2018) conducted a study in Brazil, demonstrating how board games can facilitate experiential learning, critical thinking, and engagement in organic chemistry for 12th graders and undergraduates. Similarly, Cardinot and Fairfield

(2019) found that developing and implementing board games in astronomy facilitated students' understanding of concepts and promoted social skills.

Barton et al. (2018) observed that physical board games enhanced social interactions among children with disabilities and their peers. The study revealed that board games positively impacted the relationship between children, improving social skills and facilitating the sharing of perspective, as consistent with the findings of this research. Fang et al. (2016) compared games and digital gameplay, finding that board game players displayed more sympathetic responses, satisfaction and emotional reactions, highlighting the positive impact of board games on social interactions and the development of complex social skills, as it was consistent with this research's findings.

Furthermore, da Silva Júnior et al. (2020) developed a multilingual hybrid board game for pharmacy undergraduate students. The experimental group exposed to the board game demonstrated positive opinions regarding its design, content, playability, usability and usefulness in learning the concepts of intermolecular forces. This board game promoted social cohesion and was a problem-solving class and a complementary educational tool, similar to this research's findings.

This research shared similarities with Kuo and Hsu (2020), as both studies used board games as instructional material to enhance learning outcomes. In Kuo and Hsu's study, The Robot City Board Game was used to teach seventh-grade students computational thinking. The findings showed that board games deepened student's interaction and higher thinking than the control group. Collaboration creation and an increased desire to learn were observed, indicating the positive impact of board games on learning achievement. The classroom observation in this research revealed that participants in both PBBG and CBG exhibited continuous interaction and excitement. They were

willing to ask questions with their groups and the researcher, demonstrating the engaging nature of PBBG and CBG compared to CT, such as PowerPoint Presentations.

In-depth interviews in this research identified themes of collaboration, playing board games with friends, engagement and group involvement. These themes aligned with the findings of Chen et al. (2021), who developed the board game "Element Enterprise Tycoon" for chemistry learning. Students' creative problem-solving skills improved, and the interview results highlighted enhancement in dimensions and interactivity compared to traditional teaching methods in chemistry classrooms.

Additionally, the study of Fjællingsdal and Klöckner (2020) shared similarities with this research. They conducted game nights where respondents played environmental board games and participated in subsequent focus group interviews. The findings indicated that board games made the connection between actions and impacts on the game board more salient. The application of board games also fostered social interaction in a physical, real-life setting.

7.5 Differences in Learning Motivation between CT, PBBG and CBG in Learning Science among 10-year-old Participants

In this study, the administered questionnaire unveiled substantial disparities in learning motivation among the 10-year-old participants in a Science classroom engaging with CT, PBBG, and CBG. Notably, the outcomes from Kruskal-Wallis Dunn's Post Hoc Test signify that statistically significant variations exist in the mean learning motivation scores among all conceivable pairs of the three groups (CT, PBBG, and CBG). These results indicated that using PBBG positively influenced the participant's learning

motivation. The high mean scores suggested that the participant found PBBG engaging, stimulating, and supportive of their motivation to learn Science. The findings imply that PBBG has the potential to enhance learning experiences and promote intrinsic motivation among effectively 10-year-old learners in the Science classroom.

By incorporating PBBG as a learning strategy, educators and researchers can tap into the motivational aspects of gameplay and leverage it to foster a positive and engaging learning environment. The high mean scores obtained from the questionnaire responses validate the effectiveness of PBBG in motivating young learners and emphasizing its potential as an instructional approach in Science education.

The inclusion of PBBG resulted in exceptionally high mean scores for learning motivation among the 10-year-old participants. These findings highlight the positive impact of PBBG on students' motivation to learn Science, underscoring its value as an innovative and effective teaching tool in the context of Science education for young learners. This aligned with the study of Teixeira and Lima (2023), where the "Minerals in Your Daily Life" Board Game was developed for middle school students in Portugal. Participants reported a high level of learning motivation and expressed that learning through board games made it easier to acquire knowledge.

Similarly, the findings of this research were consistent with the study of Chiang et al. (2022), which incorporated a nutrition educational board game for food and nutrition knowledge among seventh-grade students in Beijing. The findings significantly improved the student's knowledge, attitude, and behaviours. The study also found that females and those with abnormal BMI were more likely to be influenced by the educational game, resulting in positive changes in attitudes and behaviour.

Sangwanna et al. (2022) developed the Fruit-Veggie Wonderlands Board Game, and participants reported high satisfaction after playing the game. The scores for game enjoyment, aesthetics, overall game preference, duration, and ease were consistently high. These findings aligned with the positive impacts observed in PBBG and CBG in this research.

This research shared similarities with the study of Stanley (2022), as both studies revealed a significant association between students' perception and Learning Effectiveness. Students reported that the game, whether the "Carbon Compound" game in Stanley's study or the application of PBBG in this research, helped them understand the subject matter better and the lesson more exciting and helpful.

Lin and Cheng (2022) examined learning motivation among sixth-grade students using board games for factorisation learning, similar to this research's findings. These findings revealed improved learning motivation and attitude among the students, similar to the results of this research. Lin and Wang (2022) conducted a study on applying a technology-enhanced board game in mathematics education for primary school students. The findings demonstrated a higher level of technology acceptance and increased learning motivation among the students after playing the digital board game, supporting the notion that the digital version of board games can enhance learning motivation compared to CT.

Hayati et al. (2022) developed the Sciencemopoly Game to assess junior high school students' learning motivation on the digestive system. The findings from questionnaires showed that the participants considered the game a suitable teaching medium for Science learning, indicating high scores and positive feedback. The classroom observation in this research revealed participants' willingness to engage with PBBG and CBG, with CL in the Science classroom, and positive responses were observed while

playing the board games. The in-depth interviews also highlighted that participants understood the learning content better when using board games and expressed motivation and acceptance of these new learning approaches compared to the CT of PowerPoint Presentation. This aligned with the study by Nordin et al. (2022), which observed undergraduate students' readiness and interest in using the REV-OPOLY board game in learning, resulting in positive feedback.

Montejo and Fernández (2021) developed the Chemical Battleship Board Game for learning the periodic table, which aligned with this research's use of PBBG with CL. The findings demonstrated high acceptance of the board game among students, arousing their interest and curiosity in the first group and improving their knowledge in the latter group. Students' subjective perception of their knowledge and understanding of the periodic table improved, as reflected in their improved marks. The study by Lin et al. (2021) focused on a board game assimilating AR into health education. The findings indicated that participants who experienced the integration of AR into the health education board game showed significant learning motivation, suggesting that the integration of AR technology significantly influenced health education.

Similarly, Meekaew and Yasri (2020) created the "MircoEvo" board game to enhance high school students learning performance in microevolution. Their findings showed statistically significant improvements in participants' mean scores and scientifically accurate answers after playing the game, while the percentage of misunderstanding decreased. Premthaisong and Srisawasdi (2020) developed a multi-player digital board game for third-grade students, comparable to the application of CBG in this research for 10-year-old participants. Interviews with the students indicated positive

acceptance of learning and playing digital board games, particularly in general Science topics about living and non-living things.

The results demonstrated that all the participants exhibited a remarkably high level of motivation, as indicated by their mean score interpretation. These findings highlighted the positive impact of CBG on learning motivation in Science classrooms. The participants' enthusiastic responses and high mean scores suggest that CBG effectively engages and motivates learners, fostering a positive learning experience. By incorporating CBG into Science education, educators can tap into students' intrinsic motivation and promote a deeper understanding of scientific concepts. The findings of this research underscored the significant role of PBBG and CBG in fostering learning motivation among 10-year-old participants in Science education. The high mean scores across various items reflected the participant's positive attitudes, engagement, and enthusiasm toward learning Science through these game-based approaches. These findings emphasized the value of incorporating game-based strategies to enhance motivation and promote effective learning experiences for young learners.

It was consistent with the study of Ang et al. (2020), as they developed physical and digital educational escape rooms for teaching chemical bonding, similar to this research's focus on a game-based active learning approach. The findings indicated promising outcomes for physical and digital board games, as participants could apply what they learned in the lectures in a fun and exciting environment.

This research shared similarities with the study conducted by Sari and Rezeki (2019), where an ingenious circuit board game was created to teach chemistry and implement PBBG and CBG with CL. Both studies collected data through questionnaires and observations, and the findings showed highly positive responses from students and

teachers. This aligned with the findings of this research, demonstrating a higher level of learning motivation after applying PBBG and CBG with CL. The study by Butsarakam and Yasri (2019) supports this research, as they incorporated the Female Reproductive (FEREP) Board Game to investigate its effectiveness on conceptual understanding and attitudes toward learning the menstrual cycle. Similar to this research, they used pre-tests, post-tests, and questionnaires, and the findings revealed that the board game promoted conceptual understanding and positive attitudes toward learning. The positive attitudes toward learning, as indicated by the questionnaires, increased after playing the game, consistent with the findings of this research, which showed a high level of learning motivation towards Science topics after implementing PBBG and CBG with CL.

The study by McOwat and Stanley-Wall (2018) developed the Biofilm Building Board Game to reinforce knowledge of biofilm formation among young learners. The findings showed that children expressed interest, enjoyment and desire in Science to learn more about biofilm, which aligned with the findings of this research, where participants showed a high level of learning motivation after implementing PBBG and CBG with CL.

Kibala (2018) supported the findings of this research, as their Science board game aimed to increase the student's motivation and achievement in learning electric circuits. The findings revealed that the creative aspect of the board game was a motivating factor for students, and gameplay has a positive effect on motivation and achievement compared to other methods of presenting information.

Apostolellis et al. (2018) developed the collaborative digital and physical board game "Pump that Press!" and observed the responses of junior high school students. The findings indicated that student performance during the game and post-game activities was satisfactory, especially for those motivated to participate due to personal interest or finding

the activity rewarding. This was consistent with this research's results, where PBBG and CBG, with CL, were identified and analyzed, leading to increased motivation in learning selected topics.

Olympio and Alvin (2018) conducted a study on the design of a physical board game to facilitate collaboration, retention of information and enhance enthusiasm and motivation among participants for promoting active and healthy ageing. This aligned with the findings of this research, where the use of PBBG and CBG, with CL, contributed to increased learning motivation among 10-year-old participants in the Science classroom.

Underberg-Goode and Smith (2018) developed board games for learning concepts of Andean culture and folklore, targeting American middle-school students. The findings showed increased motivation among participants to learn about Peru and explore other cultures after their exposure to the board games. This was consistent with the positive impact of PBBG and CBG on learning motivation observed in this research.

The Gonzalo-Iglesia et al. (2018) study focused on Spanish students' experiences in Communication and Biochemistry studies, using commercial board games for the course content. The post-game feedback indicated that board games successfully motivated the participants to learn, fostering high levels of engagement and developing transversal skills such as teamwork and communication. This aligned with the findings of this research, highlighting the positive impact of PBBG and CBG with CL on learning motivation and social interaction.

The findings of this research were similar to the study of Yeh et al. (2017), as it was focused on comparing the effects of a Technology-Enhance Board Game (TEBG) with traditional teaching methods on English learning motivation among undergraduate

students. These findings showed that participants' English learning motivation was promoted after implementing the post-test, supporting the notion that game-based approaches can enhance motivation in language learning.

7.5 Summary

This chapter discusses the study's findings, specifically addressing gender differences, academic performance, social interaction and learning motivation when implementing CT, PBBG and CBG with CL. It also refers to previous studies that support and are considered and aligned with the findings of this research.

In the following chapter, the study summarises its main points, presents a conclusion from the findings, discusses the implication of the research's results, and highlights any limitations that may have affected the research. Additionally, recommendations for future research directions were provided. Overall, this chapter served as a comprehensive discussion and analysis of the study's findings, drawing connections to existing research and providing insights into the significance and implications of the study's results.

CHAPTER 8

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

8.1 Introduction

In this chapter, the research summarized the findings obtained from the previous chapters. It highlighted the key results and observations on the implementation of CT, PBBG and CBG, with CL in determining the gender differences, change scores from pre-test to post-test, as well as the mean scores for social interaction and learning motivation among 10-year-old participants from National-Type Chinese-Primary Schools, Sibu.

Based on the findings, the chapter concluded the gender differences between CT, PBBG and CBG groups and the impact of the different teaching methods on the mentioned factors. It discusses how implementing PBBG and CBG with CL have positively affected academic performance, social interaction, and learning motivation compared to the CT.

Furthermore, the chapter explored the implications of the research's results. It discussed the valuable insights from the study on gender differences between CT, PBBG and CBG and the potential benefits and practical applications of using PBBG and CBG with CL approaches in the Science classroom for 10-year-old participants. The implications may include improved engagement, increased knowledge, enhanced problem-solving skills, and positive motivation towards Science learning.

The chapter provides recommendations for future research in this area. It suggests further exploration and investigation into specific aspects, such as the design of board games, technology integration, facilitators' role, and the long-term effects of using PBBG and CBG in different educational contexts.

8.2 Summary of the Findings

The primary motivation behind this research was to assess the effectiveness of the CT, PBBG and CBG, with CL, in enhancing the academic performance, social interaction and learning motivation of 10-year-old participants. This research aimed to fill the research and theoretical gaps in the context of National-Type Chinese Primary Schools in Sibu, where no previous studies had been conducted. The selection of 10-year-old participants was based on their suitability for understanding the Year 4 Science syllabus and their importance in the success of the research. They have been recognised as the most important part of making this research successful.

The overarching objectives of this research were as follows:

1) To design PBBG and CBG specifically tailored for 10-year-old participants' Science learning.

2) To develop PBBG and CBG that effectively support and enhance the Science learning experience of 10-year-old participants.

3) To compare the gender differences between CT, PBBG and CBG in learning Science among 10-year-old participants

4) To compare the differences in pre-test and post-test scores between CT, PBBG and CBG in learning Science among 10-year-old participants.

5) To analyze the differences in social interaction between CT, PBBG and CBG in learning Science among 10-year-old participants.

6) To analyse the differences in learning motivation between CT, PBBG and CBG in learning Science among 10-year-old participants.

The findings indicated a clear inclination among 10-year-old participants, particularly the gender differences between CT, PBBG and CBG, with CL, to engage with and benefit from applying those teaching methods regarding their academic performance, social interaction and learning motivation. However, subtle differences were observed between the various versions of board games used to teach selected Science topics from the Year 4 Science syllabus at National-Type Chinese Primary Schools.

8.2.1 How do genders differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

The research aimed to determine the gender differences between CT, PBBG and CBG, with CL among 10-year-old participants at National-Type Chinese Primary Schools. After implementing those three teaching methods, the pre-test, post-test, and questionnaire were applied to collect the data, particularly for male and female participants. The findings revealed that the gender factor does not significantly influence the change scores from pre-test to post-test, mean scores of social interaction and learning motivation achieved through CT, PBBG and CBG, with CL in this research.

8.2.2 How do pre-test and post-test scores differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

This research aimed to examine the effectiveness of three teaching methods, CT, PBBG and CBG, with CL, by conducting pre-test and post-test assessments among 10-year-old participants. The study focused on three Science topics: "Properties of Light", "Energy", and "Materials". The pre-test and post-test results indicated similar trends for all

three teaching methods, although the change scores varied. Notably, the change scores achieved through implementing PBBG were higher than those obtained through CT (PowerPoint Presentation) and CBG with CL. These findings suggest that PBBG is the most effective method for facilitating the learning of Science topics compared to the other two methods.

8.2.3 How does social interaction differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

Multiple research instruments were employed to investigate the social interaction in Science learning using CT, PBBG and CBG, with CL among 10-year-old participants at National-Type Chinese Primary Schools. Questionnaires were administered after each of the three teaching methods, while classroom observation and interviews were conducted exclusively for the groups using the board games.

Based on the questionnaire results, a statistically significant difference was observed among the three teaching methods. The PBBG group exhibited the highest perception of social interaction, as indicated by its higher mean score and lower standard deviation than the CT and CBG groups.

This finding was supported by classroom observation, which revealed strong social interaction within both the PBBG and CBG groups. Participants in these groups showed enthusiasm and actively engaged in discussions related to Science questions, surpassing the level observed during the application of CT, such as PowerPoint Presentations. The board games fostered communication and knowledge sharing, resulting in social interaction among the participants.

In-depth interviews were conducted with the PBBG and CBG groups. The findings demonstrated that both groups collaboratively worked and learned with their fellow group members while using the respective board games. They expressed their positive experiences of active engagement and group involvement during gameplay. Participants willingly shared their perceptions, highlighting the positive impact of board games on their Science learning.

8.2.4 How does learning motivation differ between CT, PBBG and CBG in learning Science among 10-year-old participants?

Similar to the previous aspect, this research aimed to examine the learning motivation of 10-year-old participants. A questionnaire was utilized as the data collection tool to assess the level of learning motivation after implementing CT, PBBG and CBG with CL in the Science classroom. However, only PBBG and CBG, with CL, were qualitatively analyzed through classroom observation.

The findings of this research indicated that the choice of a board game, whether PBBG or CBG, positively influenced the learning motivation of the participants in the Science classroom compared to the implementation of CT methods, such as PowerPoint Presentations. These initial findings provided valuable insights into the potential benefits of game-based approaches in promoting motivation in Science education.

The classroom observation findings further supported the positive impact of PBBG and CBG, with CL, on learning motivation among 10-year-old participants. Many positive responses were observed during the classroom observation, indicating a high level of learning motivation when using both board games.

In-depth interviews revealed that the participants found it easier to understand the Science concepts while playing PBBG and CBG with CL in the Science classroom. They also expressed that both versions of the board games offered new and engaging learning approaches compared to CT. Consequently, the participants reported feeling motivated and eager to continue using the board games in future lessons.

8.3 Conclusion of the Research

The conclusion of the research is based on the investigation of 10-year-old participants in learning Science through the implementation of CT, PBBG and CBG, with CL in the Science classroom, can be summarized as follows.

i. Gender Differences: Both genders do not play a significant role in the changes in scores resulting from the utilization of CT, PBBG and CBG. It also does not appear to significantly impact the social interaction and learning motivation mean scores achieved through the use of those three teaching methods CBG in this research.

ii. Academic performance: The application of teaching methods impacted the participants' academic performance. PBBG, with CL, proved to be the most effective in helping the participants master knowledge and skills from the selected Science topics, enabling them to apply them in the Science classroom. In contrast, the CT (PowerPoint Presentation) had the lowest effectiveness in facilitating Science learning among 10-year-old participants compared to PBBG and CBG, with CL.

iii. Social Interaction: The findings of this research revealed that 10-year-old participants were aware of the different teaching methods employed. These

learning approaches stimulated social interaction in the Science classroom. Participants exhibited strong social interaction features when using teaching methods with CL, such as PowerPoint presentations, PBBG, and CBG. It was evident that participants consistently interacted with each other during collaborative work in the Science classroom. This observation was supported by the participants' comments during interviews, expressing a preference for applying both versions of board games with their friends. However, participants indicated that the CT, specifically the PowerPoint Presentation, resulted in fewer social interaction features. This was reflected in the lower mean score obtained from the administrated questionnaires.

iv. Leaning Motivation: The findings highlighted that the different learning approaches, including CT, PBBG and CBG, with CL, influenced participants' learning motivation. Among these approaches, PowerPoint Presentation had the lowest impact on learning motivation, while PBBG and CBG demonstrated higher effectiveness. The results suggested that PBBG and CBG, with CL, are equally important for promoting higher learning motivation among 10-year-old participants. On the other hand, the CT received the lowest mean score compared to the other two board games.

8.4 Implication of the Research

The findings of this research contributed to our understanding of how the use of physical and digital board games influences academic performance, social interaction and learning motivation in the Science classroom. This research has revealed that different

teaching methods elicit varied responses and outcomes from 10-year-old participants in Science learning. These findings have important practical and theoretical implications for the field of education, particularly for educators and game designers.

8.4.1 Practical Implications

The implications of the research on gender differences between CT, PBBG and CBG are multifaceted and can provide valuable insights for educators, policymakers, and researchers. One key implication is inclusive educational strategies, as gender-based differences may not significantly influence learning outcomes when it comes to CT, PBBG, and CBG. This implies that educators can focus on inclusive teaching strategies catering to diverse students without emphasizing gender-specific approaches.

Also, this research indicates no distinct gender-based advantages or disadvantages associated with these teaching methods. This information encourages educators to diversify teaching approaches to accommodate various learning preferences and styles. Rather than adhering to a one-size-fits-all model, educators can consider a combination of CT, PBBG, and CBG through diversifying teaching methods to create a more engaging and effective educational experience.

Through this research, by demonstrating that there are no significant gender differences in learning outcomes across these teaching methods, the study contributes to efforts to break down gender stereotypes in education. Pupils should not feel confined to specific teaching methods based on gender; rather, they can explore and benefit from various approaches that suit their individual learning needs and preferences.

Undeniably, policymakers and curriculum developers may use these findings to inform decisions about educational technology and resources. Equitable access to gamified technology and digital resources is important, as this research indicates that PBBG and CBG can be effective teaching methods for all pupils, regardless of gender.

The findings of this research are of great significance to educators, including primary school teachers (Zou, 2020), secondary school teachers (Acquah & Katz, 2020) and school administrators (Aziz & Kashinathan, 2021). The research highlights the impact of teaching aids or approaches on students' academic performance, social interaction and learning motivation in the Science classroom. This emphasises the importance of educators carefully selecting appropriate teaching and learning aids or approaches when working with their students. Educators play a crucial role in incorporating elements of fun and games into the educational experience (Manojlovic, 2021). The findings suggest that board games, as demonstrated in this research, can be effective alternatives for teaching and learning activities in the Science classroom, as they have been shown to enhance academic performance, social interaction and learning motivation.

This research indicates that physical and digital board games with CL, such as PBBG or CBG, can effectively teach Science. In light of these findings, educators, especially in Science education, should be open to different interpretations and approaches to cater to the needs and requirements of their students in learning Science.

Teacher training institutions and universities have a role in preparing educators by incorporating courses based on gamification models, such as user-centred, game-centred and technology-centred approaches (González-Fernández et al., 2022). These models aimed to motivate students by integrating game design and elements into the learning environment, fostering enjoyment, engagement and sustained interest in the classroom.

Additionally, it would be beneficial for teacher trainers to understand the needs and perspectives of students in learning Science topics.

This research specifically examined the effectiveness of two distinct versions of board games, PBBG and CBG, with CL in teaching Year 4 Science topics. The findings suggested that PBBG has a greater impact on academic performance, social interaction and learning motivation than CBG with CL. Consequently, educators should focus on implementing CBG with CL, which aligns with the current emphasis on using technological tools in education in Malaysia (Ajmain et al., 2019). This approach can effectively promote higher social interaction and learning motivation among the students in future lessons.

Moreover, educators who implement student-centred and material-centred approaches, such as PBBG and CBG, with CL, should have the means to enhance teaching and learning by promoting group participation and communication among students. This facilitates increased interactions, allowing educators to monitor and intervene when necessary while moderating and guiding the tone of the social interactions (Herodotou et al., 2020).

In addition, school administrators should take responsibility for fostering learning motivation among students in the classrooms through board games, whether PBBG or CBG. This initial step is to simultaneously engage more students in playing and learning new knowledge, creating conducive learning environments that motivate students beyond CT (Ryan & Deci, 2020).

Administrators can focus on implementing board games and CL, as it goes beyond a pedagogical method. It also fosters student social interaction, providing a platform for

active socialisation and interaction while learning Science knowledge in the classrooms (Nakao, 2019). Administrators should be well-prepared to utilize these board games and provide adequate training to teachers on how to manage their implementation, becoming active agents in promoting mastery of learning knowledge among their students.

This research is also valuable for the MOE, State of Sarawak Education Department and Sibu District Education Office in ensuring the continued implementation of board games in the future. Curriculum developers should focus on the long-term perspective, particularly in applying PBBG and CBG with this research to enhance academic performance, social interaction and motivation among 10-year-old participants in learning Science at National-Type Chinese Primary Schools.

Furthermore, for game designers, this research highlights the need to design suitable board games that cater to the needs of students in the classroom. Respondents provided feedback on the frequent interaction they experienced while playing PBBG or CBG with this research. Therefore, game designers should prioritize social interaction in designing and developing board games to facilitate students' CL.

They should also consider students' perceptions and ensure that game elements and mechanics are appropriate and well-accepted in the classroom, providing them opportunities to enjoy the board games and engage in effective learning experiences. Additionally, this research can guide game designers in understanding the implementation of PBBG and CBG with CL, enabling them to make informed decisions and develop relevant board games for other subjects in the future.

8.4.2 Theoretical Implications

The result of this research aligns with Engestrom's expanded AT (Engestrom, 1987) and SCT (Muniyappan, 2018), as both theories support the identification of academic performance, social interaction and learning motivation among 10-year-old participants in National-Type Chinese Primary Schools. Engestrom's expanded AT emphasises the role of various elements as mediators, including tools (PBBG and CBG), subject (10-year-old participants), object (Science learning), rules (communication etiquette), community (peers), and division of labour (collaborative activities). Similarly, SCT highlights the importance of each participant in the group, whether in PBBG or CBG groups, playing a social role and considering the opinions and comments of others to achieve collaborative work. SCT also emphasises the participants' learning motivation in the Science classroom when implementing CT, PBBG and CBG with CL.

This research showed that 10-year-old participants are highly relevant, and their perceptions and opinions regarding implementing CT, especially PBBG and CBG, with CL in the Science classroom, have been considered. Most participants viewed both versions of board games positively, recognising the opportunity to engage in frequent play and learn new knowledge in a more enjoyable and exciting learning environment.

In summary, Engestrom's expanded AT and SCT supported the notion that implementing PBBG and CBG, with CL, can enhance the academic performance, social interaction and learning motivation of 10-year-old participants. It also highlighted the importance of sociocultural settings and the need for a holistic approach to learning, going beyond individual-level processes (Bower, 2019).

8.5 Limitations of the Research

Several limitations observed during this research should be addressed in future studies. Firstly, the research focused solely on participants from National-Type Chinese Primary Schools and did not include participants from National-Type Primary Schools or National-Type Tamil Schools. It would be valuable to investigate whether the academic performance, social interaction and learning motivation of participants from different school types are positively or negatively affected by implementing the CT, PBBG and CBG with CL. Future studies should consider including participants from a wider range of school types to provide a more comprehensive understanding of the effects of these teaching methods.

Exploring the long-term implications and sustainability of integrating PBBG and CBG into educational settings is crucial for understanding their impact on teaching and learning. Continued use of PBBG and CBG in educational settings has the potential to lead to sustained improvements in learning outcomes. Over time, students may develop deeper conceptual understanding, critical thinking skills, and problem-solving abilities through repeated engagement with these interactive and collaborative learning tools. Long-term utilization of PBBG and CBG can contribute to sustained levels of student engagement and motivation. By offering enjoyable and immersive learning experiences, these games can maintain students' interest in the subject matter and foster a positive attitude towards learning, which is essential for long-term academic success. Sustainable integration of PBBG and CBG into the curriculum involves aligning these resources with educational objectives and standards. Educators need to carefully select and design games that complement the curriculum content and learning goals, ensuring that they address specific learning outcomes while providing opportunities for student collaboration and inquiry-

based learning. Long-term sustainability requires ongoing professional development for teachers to effectively integrate PBBG and CBG into their instructional practices. Educators need support and training to incorporate game-based learning strategies, adapt teaching methods, and effectively facilitate student collaboration in the classroom. Sustainable implementation of PBBG and CBG necessitates ongoing investment in resources, including the development of new games, updates to existing ones, and maintenance of technology infrastructure. Schools and educational institutions may need to allocate funds and allocate dedicated staff to support the ongoing integration and sustainability of game-based learning initiatives. Continuous research and evaluation are essential for assessing the long-term impact of PBBG and CBG on student learning outcomes, engagement, and motivation. Longitudinal studies can provide valuable insights into the effectiveness of these approaches over time, informing decision-making and improvement efforts in educational settings. Lastly, as technology evolves, the design and delivery of CBG may change to leverage emerging technologies such as virtual reality, augmented reality, or artificial intelligence. Sustaining the relevance and effectiveness of CBG over the long term requires adaptation to technological advancements and evolving pedagogical practices.

The restricted age range and specific demographic of participants may limit the generalizability of the study findings. Since the study only includes ten-year-old students from National-Type Chinese Primary Schools in Sibu, the results may not be applicable to students of different ages, educational backgrounds, or geographical locations. Consequently, caution should be exercised when extrapolating the findings to broader populations. The young age of the participants introduces developmental considerations that may affect data collection methods. Ten-year-old children may have varying levels of

cognitive, social, and emotional development, which could influence their understanding of the research instruments, their ability to articulate responses, and their engagement during data collection activities. Researchers need to adapt data collection methods to accommodate the developmental characteristics of the participants adequately. Young participants may have limited understanding and communication skills, which can pose challenges during data collection. They may struggle to comprehend complex instructions, express their thoughts and experiences accurately, or stay focused during interviews or surveys. Researchers must employ age-appropriate language, visual aids, and interactive techniques to facilitate communication and ensure the validity and reliability of the collected data. The young age of the participants may increase the likelihood of response bias in self-reported data collection methods. Children may provide socially desirable responses, mimic adult behaviour, or rely on external cues when answering questions, leading to inflated or distorted results. Researchers should employ strategies to minimize response bias, such as using neutral language, providing assurances of confidentiality, and varying data collection methods to triangulate findings. The scarcity of available literature on the implementation of board games in Science learning within the context of Sibu District, Sarawak, further complicates the data collection process. Without a robust theoretical framework or empirical evidence specific to the study context, researchers may encounter difficulties in designing research instruments, formulating research questions, and interpreting the findings. Consequently, researchers may need to draw insights from related fields or adapt methodologies to suit the unique characteristics of the study context.

Expanding the scope of the research beyond primary schools in Sibu to include secondary schools, colleges, or universities aligns with global educational trends aimed at fostering innovation, inclusivity, and collaboration in teaching and learning practices.

Inclusive education emphasizes catering to diverse learning needs and involving all stakeholders in the educational process. Including secondary schools, colleges, or universities in the research allows for the exploration of how board game-based learning approaches, such as PBBG and CBG, with collaborative learning (CL), can support students with varying abilities, backgrounds, and educational levels. By examining the perspectives and experiences of stakeholders across different educational settings, the research can provide insights into inclusive practices that promote academic achievement, social interaction, and learning motivation in science education. As technology continues to play a significant role in education, examining the integration of CBG with CL expands the research's relevance within global educational trends. Secondary schools, colleges, and universities often have access to advanced technological resources and digital platforms, making them ideal settings for investigating the impact of digital board games on science education. Exploring how CBG, alongside PBBG, contribute to digital literacy, information literacy, and technology-enhanced learning can inform educational practices aimed at preparing students for the digital age. Global educational trends emphasize interdisciplinary and cross-curricular integration to foster holistic learning experiences and address complex real-world challenges. By expanding the research to include diverse educational settings, the study can explore how board game-based learning approaches intersect with other subject areas, such as mathematics, language arts, and social studies. Investigating interdisciplinary connections and synergies between board game-based learning and other academic disciplines enriches the research findings and promotes holistic approaches to curriculum design and pedagogy. Lastly, involving secondary school, college, and university educators in the research allows for the examination of professional development and teacher training initiatives related to board game-based

learning. By understanding teachers' perspectives, experiences, and professional development needs regarding the implementation of PBBG and CBG with collaborative learning, the research can inform tailored training programs and instructional support mechanisms to enhance teachers' pedagogical skills and confidence in using innovative teaching methods.

8.6 Recommendation for Future Research

This research has successfully implemented CT, PBBG and CBG, with CL, resulting in positive outcomes regarding participants' academic performance, social interaction and learning motivation in the Science classroom. However, several areas warrant further investigation for future studies.

Expanding the study's demographics to include a variety of age groups, socio-economic backgrounds, and educational settings is essential for achieving a more comprehensive understanding of the effectiveness of board game-based learning approaches in science education. Hence, including participants from different grade levels within National-Type Chinese Primary Schools, such as Year 1 to Year 3 or Year 5 to Year 6, allows for an exploration of developmental differences in learning outcomes and experiences. Younger students may benefit from board game-based learning approaches differently than older students due to variations in cognitive development, attention span, and learning styles. By examining the effectiveness of teaching methods across various age groups, the research can provide insights into age-appropriate instructional strategies and curriculum adaptations that cater to diverse developmental needs. Incorporating participants from diverse socio-economic backgrounds enriches the research by

considering the influence of socio-economic factors on learning outcomes and educational opportunities. Students from different socio-economic backgrounds may have varying access to resources, support systems, and learning environments, which can impact their engagement with board game-based learning approaches. By examining the effectiveness of teaching methods across socio-economic strata, the research can identify strategies for promoting equity and addressing disparities in science education. Exploring the effectiveness of board game-based learning approaches in various educational settings beyond National-Type Chinese Primary Schools, such as public schools, private schools, and alternative education programs, provides a broader perspective on their applicability and generalizability. Different educational settings may have distinct pedagogical approaches, curricular requirements, and institutional contexts that influence the implementation and outcomes of teaching methods. By conducting comparative studies across diverse educational settings, the research can identify contextual factors that facilitate or hinder the successful integration of board game-based learning approaches.

Undeniably, assessing the long-term impact of teaching methods on students' ongoing academic performance and interest in science is crucial for understanding the sustained benefits of innovative instructional approaches. Future research should aim to expand the scale of the study by including a larger number of participants from different types of educational institutions within Sibu District, Sarawak. By increasing the sample size, researchers can obtain more robust data that better represents the diverse student population. Including participants from various educational institutions, such as public schools, private schools, and alternative education programs, can provide insights into the generalizability of findings across different contexts. Extending the duration of the study to encompass a longer period allows researchers to assess the long-term effects of teaching

methods on academic performance, social interaction features, and learning motivation. Longitudinal studies track participants over time, providing valuable insights into how their experiences with different teaching methods influence their academic trajectory and sustained interest in science. By collecting data at multiple time points, researchers can identify trends, patterns, and changes in students' outcomes and attitudes toward learning. Then, including participants from other districts beyond Sibu District can offer a broader perspective on the effects of teaching methods on academic performance and engagement in science. Different geographic regions may have unique educational contexts, cultural influences, and resource availability, which can impact the implementation and outcomes of teaching interventions. By incorporating participants from diverse locations, researchers can explore how contextual factors shape students' responses to various teaching methods. It's essential to consider the influence of the learning environment outside the classroom when assessing the impact of teaching methods. Factors such as home environment, community resources, and extracurricular activities can complement classroom instruction and influence students' perceptions and attitudes toward learning. Future research should explore how these external factors interact with classroom-based interventions like PowerPoint presentations, PBBG, and CBG with CL to support students' academic achievement and motivation in science. Lastly, mixed-methods approaches can be considered to combine quantitative and qualitative data collection methods can provide a comprehensive understanding of the long-term impact of teaching methods. Quantitative measures, such as academic performance scores and standardized assessments, can offer objective metrics of student outcomes, while qualitative data from interviews, focus groups, and observational studies can capture rich insights into students' experiences, perceptions, and motivations over time.

The lack of significant gender differences in academic performance, social interaction, and learning motivation across teaching methods challenges traditional notions of gendered learning preferences. According to AT, individuals' participation in activities is influenced by their roles and interactions within social contexts. The findings suggest that the effectiveness of teaching methods may not be influenced by gender-specific factors but rather by the overall engagement and interaction fostered by the methods themselves. Future research could explore how gender stereotypes in education influence students' perceptions and experiences of different teaching methods, considering the dynamic interplay between societal expectations and individual learning preferences. The results indicating that PBBG, with CL, had the highest impact on academic performance align with both AT and SCT. AT emphasizes the importance of hands-on, interactive learning experiences in promoting cognitive development and mastery of skills. PBBG, by fostering collaborative problem-solving and active engagement, supports students' construction of knowledge and skills. Future research could investigate how specific elements of PBBG, such as collaborative problem-solving tasks, contribute to enhanced academic performance and skill development in science education, providing insights into effective instructional design strategies. The findings regarding social interaction support the principles of both AT and SCT. AT emphasizes the role of social interaction in learning, as individuals engage in joint activities and collective problem-solving to achieve common goals. PBBG and CBG, with their collaborative learning elements, provide opportunities for students to interact, communicate, and negotiate with their peers, fostering social interaction in the science classroom. Future research could explore how different modes of social interaction, such as peer collaboration, teacher-student interactions, and group discussions, contribute to students' learning experiences and outcomes in diverse educational contexts.

The results indicating that PBBG and CBG, with collaborative learning, had a higher impact on learning motivation compared to CT align with the principles of both educational theories. AT emphasizes the importance of intrinsic motivation in engaging individuals in meaningful activities within social contexts. PBBG and CBG, by providing interactive and collaborative learning experiences, promote intrinsic motivation by offering students opportunities to actively participate and invest in their learning. Future research could investigate how different aspects of collaborative learning, such as task interdependence, peer feedback, and goal setting, influence students' motivation and engagement in science education, providing insights into effective motivational strategies for instructional design.

Furthermore, to practically apply the findings of the research in classroom settings, educators can consider implementing gender-neutral teaching strategies. Develop and implement teaching strategies that are gender-neutral and focus on engaging all students regardless of gender. These strategies should prioritize active learning, collaboration, and hands-on experiences, as these were found to be effective across genders in the research. Then, it is suggested to provide a variety of learning materials and resources that cater to different learning styles and preferences. Incorporate both traditional teaching methods, such as PowerPoint Presentations and innovative approaches such as PBBG and CBG with CL to accommodate diverse student needs and preferences. Meanwhile, collaborative group activities can be encouraged where students can work together to solve problems, discuss concepts, and share ideas. It is ensured that group tasks are designed to promote equal participation and contribution from all students, regardless of gender. Lastly, it is recommended to conduct pilot programs and case studies in classrooms to evaluate the effectiveness of implementing board game-based learning approaches across different

subjects and age groups. Therefore, it is suggested to collect data on student engagement, academic performance, and learning motivation to assess the impact of these methods on diverse student populations.

Then, adapting PBBG and CBG for inclusive education involves considering diverse learning needs, including those of students with disabilities. Incorporate accessibility features into CBG, such as customizable controls, adjustable difficulty levels, and alternative input methods (e.g., keyboard shortcuts, voice commands). For PBBG, ensure that game materials are designed with clear fonts, high contrast colours, and tactile elements to accommodate students with visual impairments. Moreover, it is recommended to enhance the sensory experience of PBBG and CBG by incorporating audio cues, tactile feedback, and visual cues. This approach benefits students with different learning preferences and disabilities, such as auditory or tactile learners, and those with visual impairments. Then, allowing for customization options in CBG, such as the ability to adjust game settings, modify game rules, and personalize avatars or characters. Similarly, provide opportunities for students to create their game elements in PBBG, allowing them to tailor the experience to their individual needs and preferences. Inclusive design principles also can be applied to the development of PBBG and CBG, ensuring that game mechanics, interfaces, and content are designed with accessibility and usability in mind from the outset. This approach benefits all students, including those with disabilities, by minimizing barriers to participation and learning. Lastly, offering multiple pathways to success in PBBG and CBG, also that those students could be allowed to progress at their own pace and choose activities that align with their strengths and interests.

Integrating board-based game learning, including both PBBG and CBG, with collaborative elements can have significant benefits for science education among students

with diverse attitudes and disabilities. Both PBBG and CBG can be adapted to include accessibility features such as audio cues, adjustable text size, colour contrast options, and compatibility with screen readers. These features ensure that students with visual impairments or other disabilities can fully participate in the learning experience. Board games, whether PBBG or CBG, offer opportunities for customization and personalization. Educators can tailor the game mechanics, content, and challenges to suit the diverse learning needs of students with different abilities and attitudes towards learning. For instance, providing multiple difficulty levels or modifying rules to accommodate different learning styles can enhance inclusivity. Incorporating collaborative elements into board-based game learning promotes teamwork, communication, and peer interaction. Students with disabilities often benefit from collaborative learning environments where they can work together with their peers, share ideas, and support each other's learning. By engaging in collaborative problem-solving and group discussions, students with diverse attitudes and disabilities can develop a deeper understanding of scientific concepts. Board games can appeal to various senses, making them particularly effective for students with diverse learning preferences and disabilities. PBBG can offer tactile experiences through physical game pieces and textures, while CBG can incorporate audiovisual elements to enhance engagement. By providing multi-sensory learning experiences, board-based game learning caters to different learning modalities and helps reinforce scientific concepts. When developing board-based games for science education, designers can apply inclusive design principles to ensure that the learning materials are accessible and usable by all students, regardless of their abilities or attitudes towards learning. This may involve considering factors such as readability, navigability, and ease of use when designing game interfaces and instructional materials.

Meanwhile, a nuanced analysis of participants' feedback, encompassing negative or mixed responses, is crucial for providing a comprehensive understanding of the effectiveness of board games in educational settings and informing future research endeavours. Specifically, negative feedback from students can highlight specific areas where board game-based learning approaches may need refinement or enhancement. For example, students might express concerns about the clarity of game instructions, the relevance of game content to curriculum objectives, or the overall engagement level of the activities. Future research can focus on addressing these concerns through iterative design processes, involving students in co-design activities, and implementing strategies to improve instructional scaffolding and support. Mixed responses from students offer insights into the diverse range of experiences and perceptions encountered during board game-based learning activities. Future research can delve deeper into understanding the factors contributing to mixed responses, such as individual differences in learning preferences, prior experiences with board games, or varying levels of intrinsic motivation. By conducting qualitative inquiries, such as interviews or focus groups, researchers can elucidate the underlying reasons behind mixed responses and tailor instructional interventions accordingly. Furthermore, negative or mixed responses to board game-based learning approaches may vary across different student subgroups, including diverse demographic backgrounds, academic abilities, and learning styles. Future research can employ a more nuanced approach by examining how these factors influence student perceptions and outcomes. By conducting subgroup analyses, researchers can identify potential disparities in the effectiveness of board games and develop targeted interventions to address the needs of underrepresented or marginalized student populations. Undeniably, negative or mixed responses may also shed light on the long-term impact and sustainability

of board game-based learning initiatives. Future research can incorporate longitudinal studies to assess whether initial perceptions and experiences evolve over time and whether the benefits of board games extend beyond short-term engagement to long-term academic achievement and retention of knowledge. Additionally, researchers can explore factors influencing the integration of board games into broader educational practices, including institutional support, teacher professional development, and scalability within curriculum frameworks. Also, negative or mixed responses may be influenced by contextual factors such as school culture, resource constraints, and logistical challenges associated with implementing board game-based learning approaches. Future research can adopt a contextualized approach by examining how these factors shape student experiences and outcomes in different educational settings. By conducting case studies or comparative analyses across diverse contexts, researchers can identify best practices for overcoming implementation barriers and maximizing the effectiveness of board game-based learning initiatives.

Hence, curriculum designers should consider the developmental differences in learning outcomes and experiences across different age groups. Insights from the research can inform the development of age-appropriate instructional strategies that align with students' cognitive development, attention span, and learning styles. Policymakers should prioritize initiatives aimed at promoting equity and addressing disparities in science education, particularly among students from diverse socio-economic backgrounds. By understanding the impact of socio-economic factors on learning outcomes, policymakers can implement targeted interventions to ensure equitable access to resources, support systems, and effective teaching methods. Then, curriculum designers and policymakers should recognize the importance of contextual factors in shaping the implementation and

outcomes of teaching methods. By conducting comparative studies across various educational settings, policymakers can identify best practices and develop guidelines for adapting board game-based learning approaches to different pedagogical contexts, curricular requirements, and institutional settings. Policymakers should invest in professional development programs for educators to equip them with the knowledge and skills necessary to effectively integrate board game-based learning approaches into their teaching practices. Providing teachers with training and support will ensure the successful implementation of innovative instructional strategies across diverse educational settings. Lastly, policymakers and curriculum designers should prioritize evidence-based decision-making by drawing on research findings to inform policy and curriculum design. By staying abreast of the latest research on board game-based learning approaches, policymakers can make informed decisions that enhance the quality and effectiveness of science education for all students.

8.7 Summary

Overall, this research has provided valuable insights into the gender differences and the effects of applying CT, PBBG and CBG, with CL on academic performance, social interaction and learning motivation among the 10-year-old participants in the Science classroom for National-Type Chinese Primary Schools. The findings have practical implications for educators, game designers and school administrators, guiding them in future planning to enhance academic performance, social interaction and learning motivation based on the participants' feedback. The research employed various methods, including pre-test and post-test, questionnaires, classroom observation and interviews to assess the impact of the three teaching methods on the participants.

The results indicate no significant differences in genders towards the change scores from pre-test to post-test and the mean scores of social interaction and learning motivation among 10-year-old participants at National-Type Chinese Primary Schools. Furthermore, PBBG groups displayed the highest academic achievement and mean scores for social interaction and learning motivation compared to the CBG and CT groups. The positive feedback received during the observation and interview sessions from PBBG and CBG groups further supports these findings. The research aligns with Engestrom's expanded AT and SCT theories, validating their relevance in understanding academic performance, social interaction and learning motivation at National-Type Chinese Primary Schools.

This research is a valuable resource for educators, game designers and school administrators, encouraging them to give more attention to implementing board games for Science learning. Hopefully, this research will be recognised as an alternative reference, fostering the effective use of board games to enhance Science education in primary schools.

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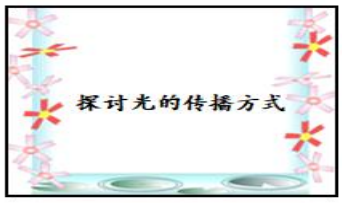
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APPENDICES

APPENDIX A: PowerPoint Slides

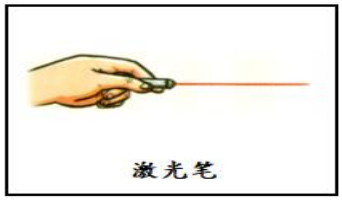








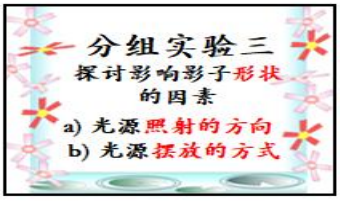


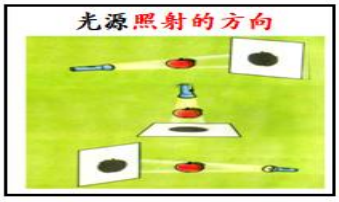


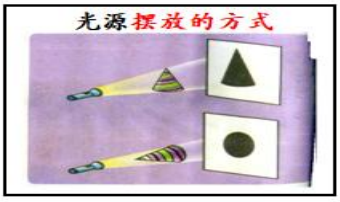


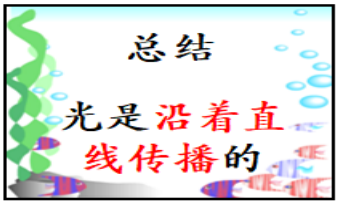


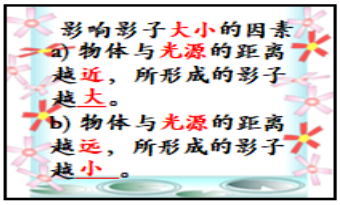


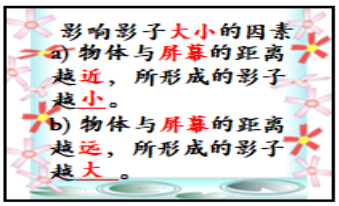


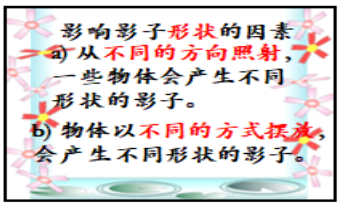





总结
光是沿着直线传播的


影响影子大小的因素
a) 物体与光源的距离越近，所形成的影子越大。
b) 物体与光源的距离越远，所形成的影子越小。


影响影子大小的因素
a) 物体与屏幕的距离越近，所形成的影子越小。
b) 物体与屏幕的距离越远，所形成的影子越大。


影响影子形状的因素
a) 从不同的方向照射，一些物体会产生不同形状的影子。
b) 物体以不同的方式摆放，会产生不同形状的影子。


个人活动卷


单元五：光的反射

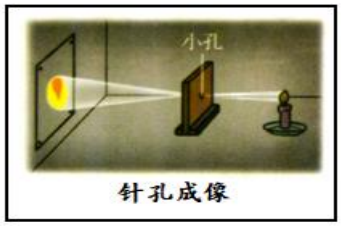

同学们照片中的倒影是如何形成的？


活动四： 镜子传光
活动步骤：
1. 首位组员操动手上的镜子，将桌灯的光，反射到下一位组员手上的镜子。
2. 将灯光引到盒子里，将黑箱的盒内照亮。
3. 写出盒子里预先隐藏的词句。


这个现象，我们称它为什么呢？


光的反射
• 当光照射在物体的表面时会改变传播的方向，这种现象叫做光的反射。
• 反射的光线仍然是沿着直线传播的。


我们能看见四周的物体是因为光线被物体反射进入我们的眼睛里。



针孔成像


舞台灯光


影子的形成


灯塔的光束

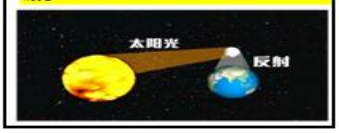

阳光透过云层

影子的形成

当光被不透明体或半透明体阻挡时，就会形成影子

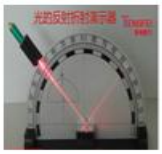
科学充电站

月球是地球的天然卫星，它并不会自己发光。我们看到明亮的月亮其实是因为它反射了太阳的光。



活动五： 光的射线图

1. 如图所示，把光束照射在平面镜上并观察反射的光束。
2. 在白纸上画出光束传播及反射的路线。
3. 把射线图绘制在科学笔记本里。



光的反射

光滑的表面

粗糙的表面

光的反射

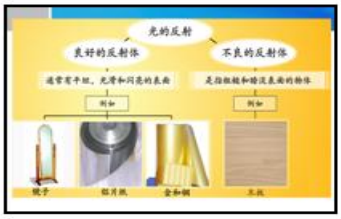


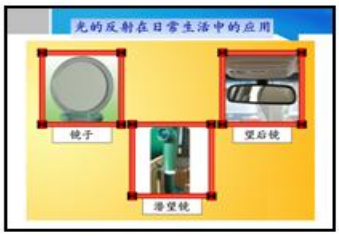
* 表面越平滑的东西，反射的能力越强。
* 光线反射的方向较有规则

光的反射－漫反射

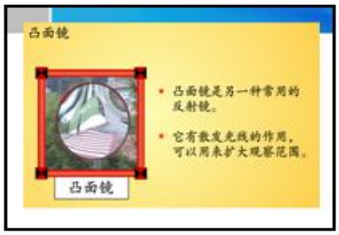


* 粗糙的表面，光线反射的方向很杂乱，很不规则，称为漫反射。



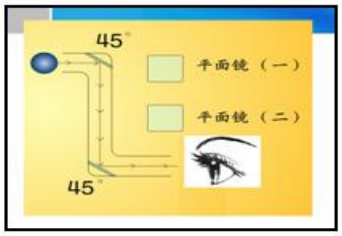

光的反射在日常生活中的应用
镜子
望远镜
潜望镜


镜子
-镜子会把光反射
-我们看到镜子里的影像是自己本来面貌的真实写照
-镜子里的影像是左右相反的


凸面镜
凸面镜是另一种常用的反射镜。
它有散发光线的作用，可以用来扩大观察范围。
凸面镜


凸面镜
凸面镜能帮助减低在马路发生的交通意外。
凸面镜


潜望镜
潜望镜能使观察者身于安全隐蔽的位置，观察难以直接观察或危险的地区。
潜水艇


45°
平面镜（一）
平面镜（二）
45°


潜望镜
坦克车
坑道
战争的时候，坦克车和坑道里都装上潜望镜，视察敌军的情况。

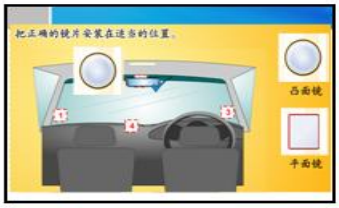

哪些物体有应用到光线被反射的原理？
直升机
汽车
帆船


哪些物体有应用到光线被反射的原理？
镜子
放大镜
眼镜

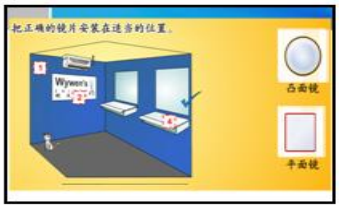

哪些物体有应用到光线被反射的原理？
望远镜
潜望镜
三棱镜

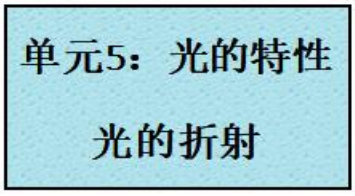

镜片专家

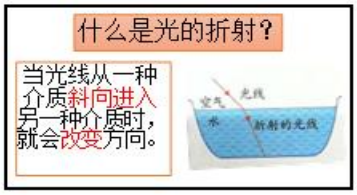

把正确的镜片安装在适当的位置。
凸面镜
平面镜

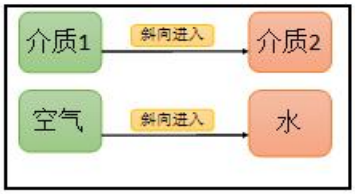

把正确的镜片安装在适当的位置。
凸面镜
平面镜


把正确的镜片安装在适当的位置。
凸面镜
平面镜

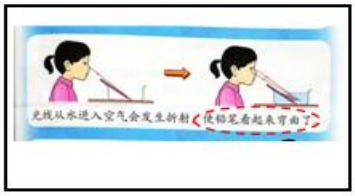

把正确的镜片安装在适当的位置。
凸面镜
平面镜


单元5：光的特性
光的折射


什么是光的折射？
当光线从一种介质斜向进入另一种介质时，就会改变方向。
空气
光线
水
折射的光线


介质1
斜向进入
介质2
空气
斜向进入
水


光的折射现象
看不见硬币
看见硬币
加水后，光的折射让硬币看起来在较浅的位置。


光线从水进入空气会发生折射
使得笔看起来弯曲了

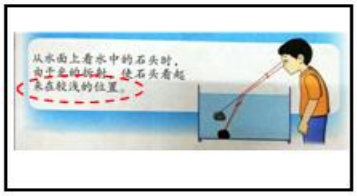

从水面上看水中的石头时，由于光的折射，使石头看起来在较浅的位置。



Figure 1: PowerPoint Slides (Chapter 5)



能的来源

食物



我们需要从食物中获取能量。

能的来源

海浪



当海浪涨潮和退潮的过程中提供能量。



动摆式海浪发电装置

能的来源

生物质



从有机废物和动物粪便等获取的能。



能的来源

化石燃料



煤、石油、天然气等燃料。

能的来源

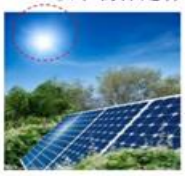
核子能



原子核分裂或聚合是所释放出来的能量。



以下物体是什么能？



太阳能

以下物体是什么能？



光能

以下器具拥有什么能？





热能

以下器具拥有什么能？



化学能

以下燃料、电池拥有什么能？



化学能

以下物体产生什么能？



电能

以下活动拥有什么能？





势能

以下器具拥有什么能？





声能

以下活动拥有什么能？





动能





核子能

能的转换

- 能可以从一种形式转换成另一种形式



家里的电器如：熨斗、烘面包机、饭锅等都是用电来操作。当电源开启后，**电能** 会使到电器的元件发热，而产生 **热能**

电能 ➡ 热能

能的转换

- 能可以从一种形式转换成另一种形式

有些电器是可以使用电池来操作，如：玩具车。电池本身拥有 **化学能**。我们在玩玩具车时，电池会产生 **电能** 使玩具车转换成 **声能**、**动能和光能**。

化学能➡电能➡声能
✚光能✚动能

能的转换

- 能可以从一种形式转换成另一种形式

有些电器是可以使用电池来操作，如：玩具车。电池本身拥有 **化学能**。我们在玩玩具车时，电池会产生 **电能** 使玩具车转换成 **声能**、**动能和光能**。

化学能➡电能➡声能
✚光能✚动能

能的转换

- 能可以从一种形式转换成另一种形式



太阳能热水器是用 **太阳能** 来操作
当太阳能电板吸收了阳光后，他会转换成 **电能**，使热水器元件发热，产生 **热能**

太阳能 ➡ 电能➡ 热能

以下器具的能的转换是什么？

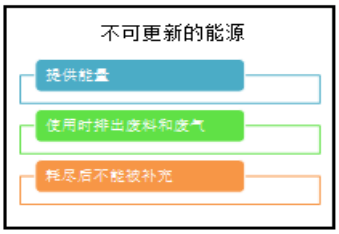
器具	能的转换
手机电脑，手机	化学能→电能→光能+声能
电脑，电视机	电能→光能+声能
手表	化学能→电能→动能 化学能→电能→光能
火柴，打火机	化学能→热能+光能
太阳能汽车	太阳能→电能→动能
洗衣机	电能→动能
吸尘机	电能→动能+声能
冷气，冰箱	电能→热能
风扇	电能→动能
电灯	电能→光能+热能
手电筒	化学能→电能→光能+热能
玩具车	化学能→电能→光能+声能+动能
音乐盒	化学能→电能→动能+声能

能源（可更新的能源）

风	太阳	水
生物质	海浪	食物

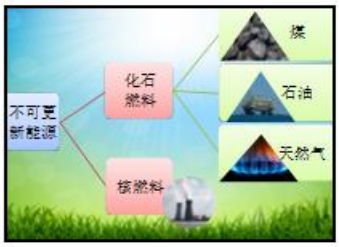

可更新的能源
提供能量
不会对环境造成污染。
可以被补充和再生


能源（不可更新的能源）
石油
煤
核子能
电池


不可更新的能源
提供能量
使用时排出废料和废气
耗尽后不能被补充


课本pg122
不可更新
和
可更新能源


不可更新能源 VS 可更新能源
不可更新能源
可更新能源
使用后，短期内无法再生。
使用后，可自动再生。
会被耗尽
不会被耗尽
会污染环境
不会污染环境


不可更新能源
化石燃料
核燃料
煤
石油
天然气


煤
• 埋藏在地下
• 燃烧后可用来发电
• 如何形成？
古代的植物被泥沙掩埋在地底
与空气隔绝
受到地底高温和高压的长久作用而形成


石油和天然气
• 经常埋藏在一起
• 石油→液体
• 天然气→气体
• 可用来发电


核燃料
• 核电站用来发电的燃料（铀 Uranium）
• 铀耗尽后不能被补充



Figure 2: PowerPoint Slides (Chapter 7)

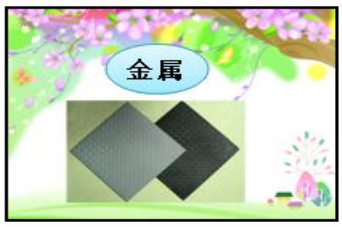

第八课
材料
的来源


木材
人造材料
橡胶
羊毛
制作物品的材料
金属
塑料
棉
土壤
丝
皮革


说一说以下物品的制作材料：
木材


橡胶


棉


金属


皮革


植物
动物
材料的来源
岩石
石油


材料的来源
棉花
橡胶
植物
树木


棉花树


棉
毛巾
袜子
手帕


橡胶树
胶乳


胶乳


门
家具
船
树木


材料的来源
羊
蚕
动物
鳄鱼
牛


羊
羊毛


蚕
丝






牛
牛皮


鳄鱼
鳄鱼皮


岩石
金属
土壤
金属和土壤是从岩石中获取的材料。
矿石中提炼各种金属以制成物品。
破例也是从土壤提炼而成的。


金属


土壤


石油
提炼+加工
塑料
人造布料


塑料

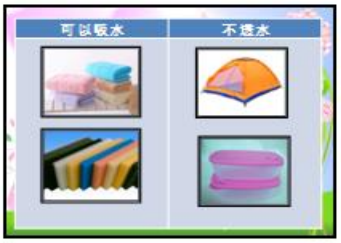

人造布料


应该响应5R原则：
再思考
(rethink)
再使用
(reuse)
再循环
(recycle)
减量化
(reduce)
再修复
(repair)


第八课
材料
的性质


不同的材料，
具有不同的性质


可以吸水
不透水


可以吸水
不透水


会吸收水分的材料


不会吸收水分的材料


有弹性
没有弹性


有弹性
受到外力会改变形状，外力消失后会恢复原状的材料。


没有弹性
受外力时改变形状，但是外力消失后不能恢复原状的材料。


会浮
会沉


会浮
当放入水里时，会浮在水面的材料。


会沉
当放入水里时，会沉入水底的材料。


电导体
电的绝缘体


电导体
能让电流通过的材料。


导体


电的绝缘体
橡皮
不能让电流通过的材料。




热导体
电的绝缘体



Figure 3: PowerPoint Slides (Chapter 8)

APPENDIX B: PBBG



Figure 1: PBBG (Chapter 5)



Figure 2: PBBG (Chapter 7)

Figure 3: PBBG (Chapter 8)

APPENDIX C: CBG

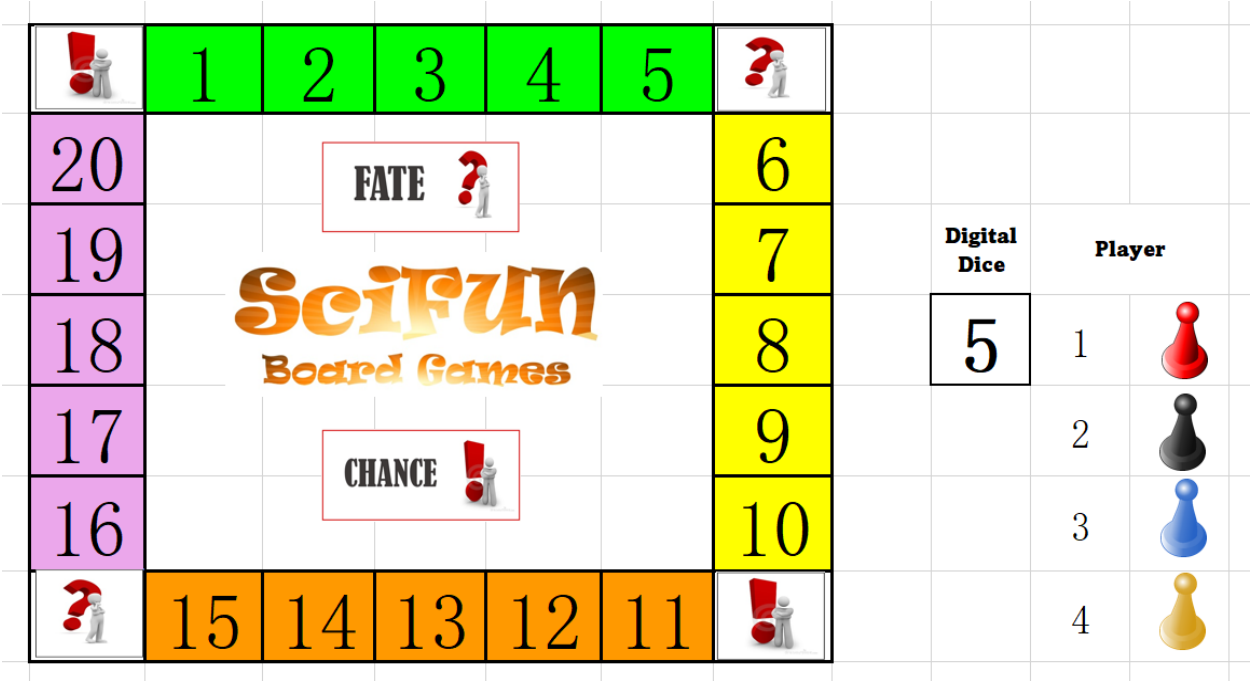


Figure 1: CBG (Chapter 5)

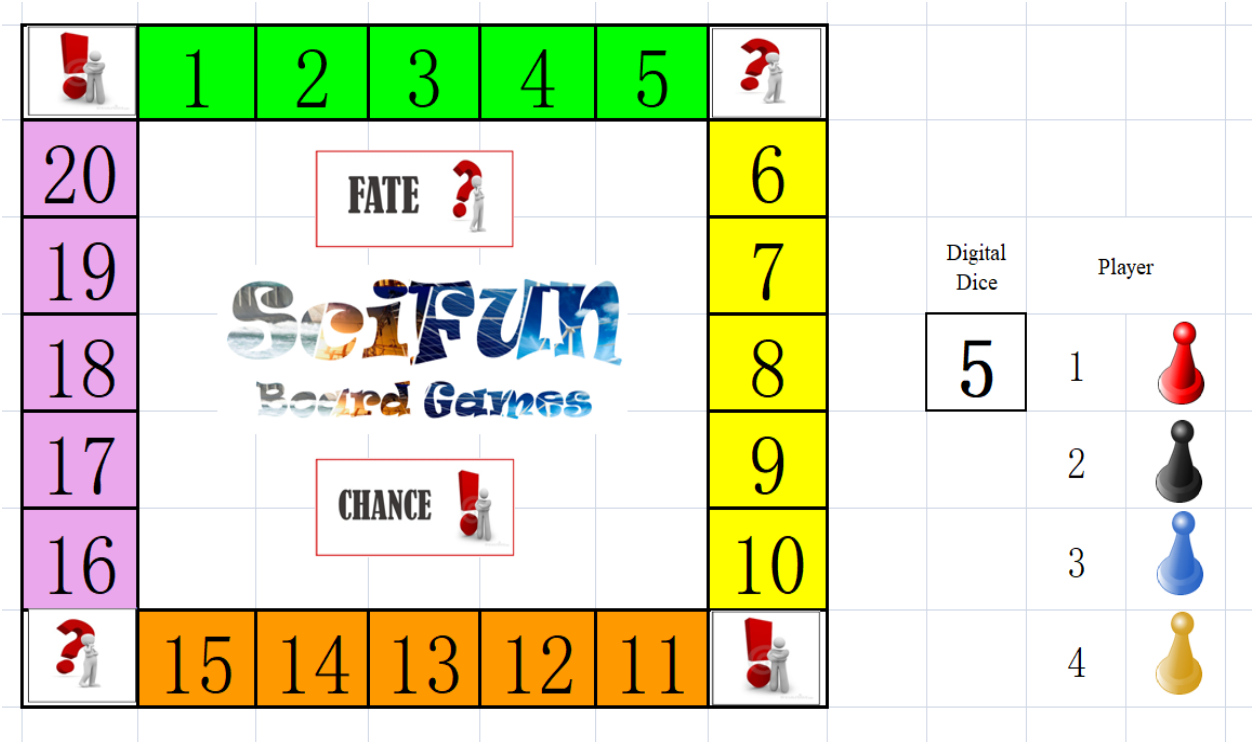


Figure 2: CBG (Chapter 7)

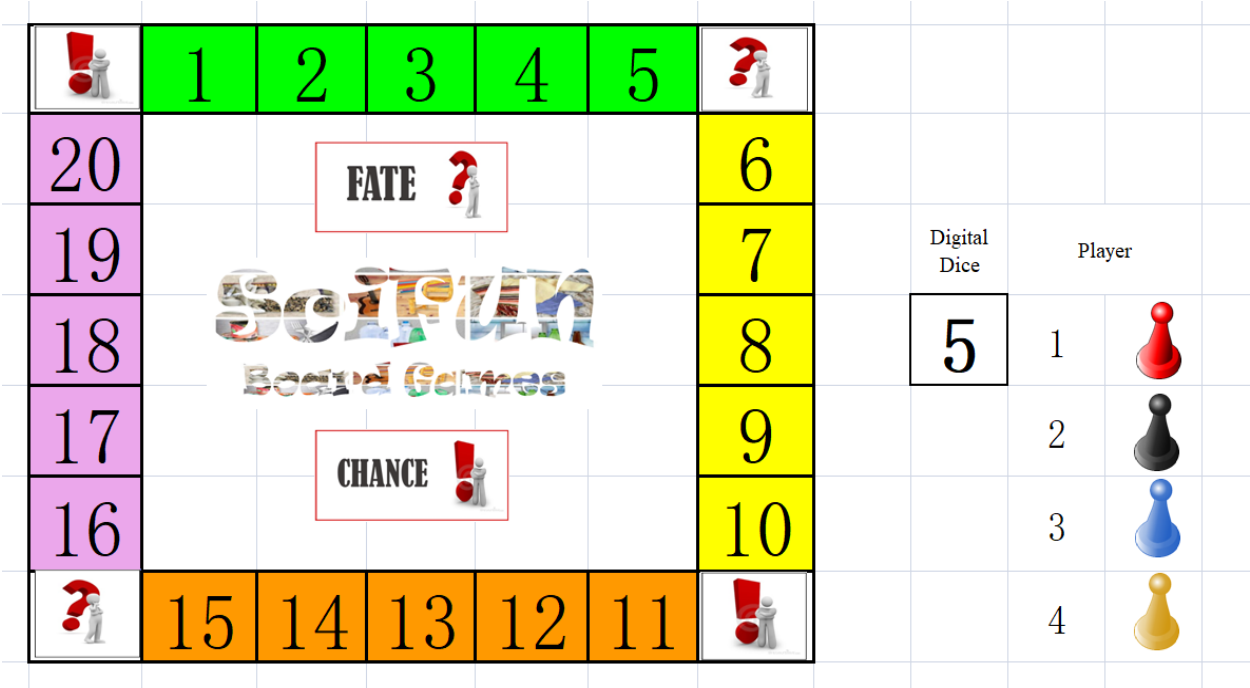


Figure 3: CBG (Chapter 8)

APPENDIX D: Science Teachers' Perceptions/Opinions toward Pre-Test/Post-Test

Science Teachers' Perceptions/Opinions toward Pre-Test/Post-Test

Name: _____ Date: _____



Faculty of Cognitive Sciences and Human Development

Research Title:

A Collaborative Learning of Year 4 Science Subject Using Computerizes Board Games

Instructions 指示:

In fact, there are three Science topics for the administration of pretest/posttest: Properties of Light, Energy and Material. Meanwhile, pretest/posttest are prepared in two different formats, which are 60 multiple-choice questions and 12 open-ended questions. These pretest/posttests are written in both English and Mandarin languages.

其实，前测/后测当中主要是以三个科学主题为主，那就是“光的特征”、“能”以及“材料”。 与此同时，前测/后测是以两种不同的形式准备的，那就是 60 道选择题和 12 道短结构开放式的问题。 这些前测/后测是用英语和华语准备的。

Section A 甲组

Each questions have 4 options which are A, B, C and D. Based on your teaching experience, please choose the option that you think the best fit. There are 5-point Likert Scale for you to choose. If you strongly agree with the question and its translation, just circle '5'; if you strongly disagree with the question as well as its translation, please circle '1'. If the question with the translated language is more or less agree or disagree for you, pick the point between 2 and 4 that best describes it.

每个问题有 4 个选项，分别是 A、B、C 和 D。请根据您的教学经验来选择您认为最合适的选项。其中有 5 点李克特量表来供您选择。如果您非常同意该题目和有关翻译的话，请圈选“5”。反之，如果您非常不同意该题目及其翻译的话，请圈选“1”。 如果翻译语言的题目对您来说或多有些少许同意或不同意的话，请在 2 到 4 之间来选择最能描述它的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Moderate

中等

4 – Agree

同意

5 – Strongly Agree

非常同意

Topic 课题:

Properties of Light 光的特征

No. 题目	Scales 评分				
1.	1	2	3	4	5
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5
7.	1	2	3	4	5
8.	1	2	3	4	5
9.	1	2	3	4	5
10.	1	2	3	4	5
11.	1	2	3	4	5
12.	1	2	3	4	5
13.	1	2	3	4	5
14.	1	2	3	4	5
15.	1	2	3	4	5
16.	1	2	3	4	5
17.	1	2	3	4	5
18.	1	2	3	4	5
19.	1	2	3	4	5
20.	1	2	3	4	5

Topic 课题:

Energy 能

No. **题目**	**Scales** **评分**				
1.	1	2	3	4	5
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5
7.	1	2	3	4	5
8.	1	2	3	4	5
9.	1	2	3	4	5
10.	1	2	3	4	5
11.	1	2	3	4	5
12.	1	2	3	4	5
13.	1	2	3	4	5
14.	1	2	3	4	5
15.	1	2	3	4	5
16.	1	2	3	4	5
17.	1	2	3	4	5
18.	1	2	3	4	5
19.	1	2	3	4	5
20.	1	2	3	4	5

Topic 课题:

Material 材料

No. **题目**	**Scales** **评分**				
1.	1	2	3	4	5
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5
7.	1	2	3	4	5
8.	1	2	3	4	5
9.	1	2	3	4	5
10.	1	2	3	4	5
11.	1	2	3	4	5
12.	1	2	3	4	5
13.	1	2	3	4	5
14.	1	2	3	4	5
15.	1	2	3	4	5
16.	1	2	3	4	5
17.	1	2	3	4	5
18.	1	2	3	4	5
19.	1	2	3	4	5
20.	1	2	3	4	5

Section B 乙组

The following questions are open-ended. Based on your teaching experience, please choose the option that you think the best fit. There are 5-point Likert Scale for you to choose. If you strongly agree with the question and its translation, just circle '5'; if you strongly disagree with the question as well as its translation, please circle '1'. If the question with the translated language is more or less agree or disagree for you, pick the point between 2 and 4 that best describes it.

以下的题目格式是以开放式为主的。请根据您的教学经验来选择您认为最合适的选项。其中有 5 点李克特量表来供您选择。如果您非常同意该题目和有关翻译的话，请圈选“5”。反之，如果您非常不同意该题目及其翻译的话，请圈选“1”。

如果翻译语言的题目对您来说或多有些少许同意或不同意的话，请在 2 到 4 之间来选择最能描述它的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

Topic 课题:

Properties of Light 光的特征

No. 编号	Subsections 小节	Scales 评分				
1.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	a) (iii)	1	2	3	4	5
	b)	1	2	3	4	5
2.	a)	1	2	3	4	5
	b)	1	2	3	4	5
	c)	1	2	3	4	5
	d)	1	2	3	4	5
	e)	1	2	3	4	5
3.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	a) (iii)	1	2	3	4	5
	b)	1	2	3	4	5
4.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b) (i)	1	2	3	4	5
	b) (ii)	1	2	3	4	5
	c)	1	2	3	4	5

Topic 课题:

Energy 能

No. 编号	Subsections 小节	Scales 评分				
1.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b)	1	2	3	4	5
	c)	1	2	3	4	5
	d)	1	2	3	4	5
2.	a)	1	2	3	4	5
	b) (i)	1	2	3	4	5
	b) (ii)	1	2	3	4	5
	c)	1	2	3	4	5
3.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b) (i)	1	2	3	4	5
	b) (ii)	1	2	3	4	5
	c)	1	2	3	4	5
4.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b)	1	2	3	4	5

Topic 课题:

Material 材料

No. 编号	Subsections 小节	Scales 评分				
1.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b) (i)	1	2	3	4	5
	b) (ii)	1	2	3	4	5
	c) (i)	1	2	3	4	5
	c) (ii)	1	2	3	4	5
2.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	a) (iii)	1	2	3	4	5
	b)	1	2	3	4	5
	c)	1	2	3	4	5
	d)	1	2	3	4	5
3.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b) (i)	1	2	3	4	5
	b) (ii)	1	2	3	4	5
4.	a) (i)	1	2	3	4	5
	a) (ii)	1	2	3	4	5
	b)	1	2	3	4	5
	c) (i)	1	2	3	4	5
	c) (ii)	1	2	3	4	5

Signature:

_____

( )

APPENDIX E: Science Teachers' Perceptions/Opinions toward Questionnaire Instrument

Science Teachers' Perceptions/Opinions toward Questionnaire Instrument

Name: _____ Date: _____



Faculty of Cognitive Sciences and Human Development

Research Title:

A Collaborative Learning of Year 4 Science Subject Using Computerizes Board Games

Instructions 指示:

In fact, there are two main domains for the questionnaire, which are 'Learning Motivation' and 'Social Interaction'. Basically, this questionnaire is written in both English and Mandarin languages.

严格来说，此问卷有两个主要领域，那就是“学习动机”和“社交互动”。基本上，这份问卷是以英语和华语这两种语言为主。

A) Learning Motivation 学习动机

The following questions ask about Year 4 Pupils' learning motivation. Based on your teaching experience, please choose the option that you think the best fit. There are 5-point Likert Scale for you to choose. If you strongly agree with the statement and its translation, just circle '5'; if you strongly disagree with the statement as well as its translation, please circle '1'. If the statement with the translated language is more or less agree or disagree for you, pick the point between 2 and 4 that best describes it.

以下的问题主要是针对 4 年级学生的学习动机。请根据您的教学经验来选择您认为最合适的选项。其中有 5 点李克特量表来供您选择。如果您非常同意该陈述和有关翻译的话，请圈选“5”；。反之，如果您非常不同意该陈述及其翻译的话，请圈选“1”。

如果翻译语言的陈述对您来说或多有些少许同意或不同意的话，请在 2 到 4 之间来选择最能描述它的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	1	2	3	4	5
2	If I study in appropriate ways, I will be able to learn the material of computerized board games in Science. 如果我以适当的方式学习，那么我将能够学习电脑版桌游的科学资料。	1	2	3	4	5
3	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	1	2	3	4	5
4	I think I can to use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	1	2	3	4	5
5	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	1	2	3	4	5
6	I’m certain I can understand the most difficult material presented in the computerized board games for Science	1	2	3	4	5

	subject. 我确信我能理解科学科目电脑版桌游中最难的资料。					
7	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	1	2	3	4	5
8	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	1	2	3	4	5
9	It is my own responsibility if I do not learn the material in computerized board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。	1	2	3	4	5
10	It is important for me to learn Science knowledge in these computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。	1	2	3	4	5
11	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	1	2	3	4	5

12	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。	1	2	3	4	5
13	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	1	2	3	4	5
14	When I take assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	1	2	3	4	5
15	I'm confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。	1	2	3	4	5
16	In a class like this, I prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料； 哪怕它是很难学习的。	1	2	3	4	5
17	I am very interested in the content area of these computerized board games. 我对这些电脑版桌游的内容领域很感兴趣。	1	2	3	4	5

18	If I try hard enough, I will understand the materials in the computerized board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。	1	2	3	4	5
19	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	1	2	3	4	5
20	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	1	2	3	4	5
21	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	1	2	3	4	5
22	The most satisfying thing for me in the computerized board games is trying to understand the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	1	2	3	4	5
23	I think the materials of computerized board games in this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。	1	2	3	4	5
24	When I have the opportunity in this class, I choose computerized board games that I can learn from even if they don't guarantee a	1	2	3	4	5

	good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。					
25	If I do understand the materials in the computerized board games, it is because I didn't try hard enough. 如果我确实了解电脑版卓游的材料，那是因为我还不够努力。	1	2	3	4	5
26	I like the subject matter of the computerized board games. 我喜欢电脑版桌游的主题。	1	2	3	4	5
27	Understanding the subject matter of the computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。	1	2	3	4	5
28	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	1	2	3	4	5
29	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	1	2	3	4	5
30	I want to do well in this Science classroom because it is important to show my ability to my family, friends, or others.	1	2	3	4	5

	我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。					
31	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	1	2	3	4	5

B) Social Interaction 社交互动

The following questions ask about Year 4 Pupils' learning motivation. Based on your teaching experience, please choose the option that you think the best fit. There are 5-point Likert Scale for you to choose. If you strongly agree with the statement and its translation, just circle '5'; if you strongly disagree with the statement as well as its translation, please circle '1'. If the statement with the translated language is more or less agree or disagree for you, pick the point between 2 and 4 that best describes it.

以下的问题主要是针对 4 年级学生的社交互动。请根据您的教学经验来选择您认为最合适的选项。其中有 5 点李克特量表来供您选择。如果您非常同意该陈述和有关翻译的话，请圈选“5”；。反之，如果您非常不同意该陈述及其翻译的话，请圈选“1”。如果翻译语言的陈述对您来说或多有些少许同意或不同意的话，请在 2 到 4 之间来选择最能描述它的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. **编号**	**Items** **陈述**	**Scales** **评分**				
1	Gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	1	2	3	4	5
2	Gives me a sense of social interaction. 给我一种有社交互动的感觉。	1	2	3	4	5
3	Makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。	1	2	3	4	5
4	Makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	1	2	3	4	5
5	Gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	1	2	3	4	5
6	Feels like a social experience and support with other group members. 感觉像是与其他组员有着社交体验和支持。	1	2	3	4	5
7	Gives me a sense of having other group	1	2	3	4	5

	members to share my endeavors with. 让我有着一种其他组员与我分享我的努力的感觉。					
8	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。	1	2	3	4	5
9	Gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	1	2	3	4	5

Signature:

_____

( )

APPENDIX F: Summary of Teachers' Evaluation Form toward Questionnaire

Date: 23.06.2022

Location: Computer Room

A) Learning Motivation

No.	Items	Ling Sui Ming	Koh Pei Sang	Comments
1	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	4	4	After discussion, three teachers have decided to categorise these 31 items into smaller scope, such as Self-Challenge, Self-Confidence, Assessment and learning motivation itself. Even though those 31 items are divided into three subcategories, they are still relevant to learning motivation. Based on Teacher Ling's opinion, self-challengecan expand thinking and broaden the desire of the pupils to learn Science. Based on Teacher Kohhas mentioned that self-confidence
2	If I study in appropriate ways, I will be able to learn the material of computerized board	4	3	

	games in Science. 如果我以适当的方式学习，那么我将能够学习电脑版桌游的科学资料。			can enhance the level of learning motivation.It can help them to keep motivated and learn new scientific knowledge. Meanwhile, she also stated that assessments involved also can be related to learning motivation, as the pupils are exposed to the teaching method they like, then they will have improvements as they become engaged individuals and this scenario can increase the learning motivation in Science classroom. **Self-Challenge** 1. In a Science classroom like this, I prefer Science knowledge can challenge me so that I am able to learn new things. 在这样的科学课堂上，我喜欢那些可以真正挑战我的科学只是，以便我能够学习到新的事物。 (No. 1) 2. If I am given more chances, I will be able to learn the materials of computerized board games in Science. 如果
3	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	5	5	
4	I think I can to use what I learn in Science subject in other subjects. 我想我能够将我在科学	5	5	

	科目中学到的知识运用到其他科目中。			我有着更多的机会，那么我将能够学习电脑版桌游的科学资料。 (No. 2) **<u>Self-confidence</u>** 4. MAINTAINED (No. 3) 6. MAINTAINED (No. 4) 12. MAINTAINED (No. 5) 15. MAINTAINED (No. 6) 29. MAINTAINED (No. 7) 31. MAINTAINED (No. 8) **<u>Assessment</u>** 3. MAINTAINED (No. 9) 5. MAINTAINED (No. 10)
5	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	5	5	
6	I'm certain I can understand the most difficult material presented in the computerized board games for Science subject. 我确信我能理解科学科目电脑版桌游中最难的资料。	5	5	

7	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	5	5	7. MAINTAINED (No. 11) 8. MAINTAINED (No. 12) 11. MAINTAINED (No. 13) 13. MAINTAINED (No. 14) 14. MAINTAINED (No. 15) 19. MAINTAINED (No. 16) 20. MAINTAINED (No. 17) 21. MAINTAINED (No. 18) 24. MAINTAINED (No. 19) 28. MAINTAINED (No. 20) 30. MAINTAINED (No. 21) **<u>Learning Motivation</u>** 9. MAINTAINED (No. 22) 10. MAINTAINED (No. 23) 16. MAINTAINED (No. 24)
8	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	4	4	
9	It is my own responsibility if I do not learn the material in computerized board games.	4	4	

	如果我不学习电脑版桌游中的资料，那会是我自己的责任。			17. MAINTAINED (No. 25) 18. MAINTAINED (No. 26) 22. MAINTAINED (No. 27) 23. MAINTAINED (No. 28) 25. MAINTAINED (No. 29) 26. MAINTAINED (No. 30) 27. MAINTAINED (No. 31)
10	It is important for me to learn Science knowledge in these computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。	5	5	
11	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的	3	3	

	是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。			
12	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。	5	5	
13	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他	4	4	

	大多数学生更好的成绩。			
14	When I take assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	3	3	
15	I’m confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。	5	5	
16	In a class like this, I	5	5	

	prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料；哪怕它是很难学习的。			
17	I am very interested in the content area of these computerized board games. 我对这些电脑版桌游的内容领域很感兴趣。	5	5	
18	If I try hard enough, I will understand the materials in the computerized board	5	5	

	games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。			
19	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	4	4	
20	I’m confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	4	4	

21	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	5	5	
22	The most satisfying thing for me in the computerized board games is trying to understand the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	5	5	
23	I think the materials of computerized board games in this class are useful for me to learn.	5	5	

	我觉得这堂课的电脑版桌游资料对我学习很有用。			
24	When I have the opportunity in this class, I choose computerized board games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。	5	5	
25	If I do understand the materials in the computerized board	5	5	

	games, it is because I didn't try hard enough. 如果我确实了解电脑版卓游的材料，那是因为我还不够努力。			
26	I like the subject matter of the computerized board games. 我喜欢电脑版桌游的主题。	5	5	
27	Understanding the subject matter of the computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。	5	5	

28	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	4	4	
29	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	5	5	
30	I want to do well in this Science classroom because it is important to show my ability to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能	4	4	

	力是很重要的。			
31	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	5	5	

B) Social Interaction

No.	Items	Ling Sui Ming	Koh Pei Sang	Comments
1	It gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	5	5	Overall, they are satisfied with the statement for this part, except No. 3, as it is quite similar to No. 5, which involves "the collaboration with others." Hence, they suggest changing Statement No. 3, to "Makes me feel that I work together with others in achieving goals."
2	It gives me a sense of social interaction. 给我一种有社交互动的感觉。	5	5	1. MAINTAINED 2. MAINTAINED 3. REPLACED WITH NEW STATEMENT. 4. MAINTAINED 5. MAINTAINED 6. MAINTAINED 7. MAINTAINED 8. MAINTAINED
3	It makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。	2	2	
4	It makes me feel that I am socially involved with	5	5	

	other group members. 让我有一种与其他组员进行社交活动的感觉。			9. MAINTAINED
5	It gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	5	5	
6	Feels like a social experience and support from other group members. 感觉像是与其他组员有着社交体验和支持。	5	5	
7	It gives me a sense of having other group members share my	5	5	

	endeavors. 让我有着一种其他组员与我分享我的努力的感觉。			
8	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。	5	5	
9	It gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	5	5	

APPENDIX G: Teachers' Evaluation Form toward Interview Protocol

Name: _____ Date: _____

Faculty of Cognitive Sciences and Human Development

Research Title:

A Collaborative Learning of Year 4 Science Subject Using Computerizes Board Games

Instructions 指示:

Basically, this interview protocol is written in both English and Mandarin languages.

严格来说，这份访谈协议是以英语和华语这两种语言为主。

The following questions are to identify the social interaction features and evaluate the extent of learning motivation in learning Science using Computerized Board Games (CBG) with collaborative learning. Based on your teaching experience, please choose the option that you think the best fit. There are 5-point Likert Scale for you to choose. If you strongly agree with the statement and its translation, just circle '5'; if you strongly disagree with the statement as well as its translation, please circle '1'. If the statement with the translated language is more or less agree or disagree for you, pick the point between 2 and 4 that best describes it.

以下的问题主要是探讨运用电脑版桌游（CBG）和协作学习法来识别社交互动的特征以及评估学习科学的动机程度。请根据您的教学经验来选择您认为最合适的选项。其中有 5 点李克特量表来供您选择。如果您非常同意该陈述和有关翻译的话，请圈选“5”；。反之，如果您非常不同意该陈述及其翻译的话，请圈选“1”。 如

果翻译语言的陈述对您来说或多有些少许同意或不同意的话，请在 2 到 4 之间来选择最能描述它的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. **编号**	**Items** **陈述**	**Scales** **评分**				
1.	Tell me about yourself. 介绍一下你自己。	1	2	3	4	5
2.	Do you know how to use electronic devices and learn knowledge? 你知道如何使用电子设备和学习知识吗?	1	2	3	4	5
3.	Do you enjoy learning Science? Why? 你喜欢学习科学吗？ 为什么?	1	2	3	4	5
4.	What do you think about computerized board games?	1	2	3	4	5

	你对电脑版桌游有什么看法?					
5.	Do you think computerized board games are new for you? Please give your opinion. 你认为电脑版桌游对你来说是新事物吗？ 请发表你的意见。	1	2	3	4	5
6.	Do you understand the content when you learn through computerized board games in the classroom? Why? 在课堂上时通过电脑版桌游学习的内容，你是否理解？ 为什么?	1	2	3	4	5
7.	Do you like computerized board games to help you figure out what the Science materials are about? Why? 你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗？ 为什么?	1	2	3	4	5
8.	Do you learn a lot after using computerized board games in the classroom? Please give examples. 在课堂上玩电脑版桌游后，你会学到很多吗？ 请举例。	1	2	3	4	5
9.	Do you like using computerized board games to explain the contents or answer questions? Why? 你喜欢用电脑版桌游解释内容或回答问题吗？ 为什么?	1	2	3	4	5
10.	Do you like to use computerized board games to list their Science materials? Why? 你喜欢用电脑版桌游列出其中的科学资	1	2	3	4	5

	料吗？ 为什么？					
11.	Do you like to work individually or collaboratively? Why? 你喜欢单独还是一起进行活动？ 为什么？	1	2	3	4	5
12.	Do you like to use computerized board games with your friends? Why? 你喜欢和朋友一起玩电脑版桌游吗？ 为什么？	1	2	3	4	5
13.	Do you like to engage in a group activity to discuss Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？为什么？	1	2	3	4	5
14.	Do you like to communicate with other group members while you are involved in using computerized board games? Why? 在玩电脑版桌游的同时，你喜欢和其他组员交流吗？ 为什么？	1	2	3	4	5
15.	Do you relate the Science materials with the usage of computerizes board games? Why? 你是否会将科学材料与电脑版桌游的运用联系起来吗？ 为什么？	1	2	3	4	5
16.	Do you feel motivated to learn Science after implementing computerized board games? Why? 实施电脑版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？	1	2	3	4	5

17.	Are computerized board games different from conventional teaching methods? Why? 电脑版桌游与传统教学方法有什么不同？ 为什么？	1	2	3	4	5
18.	Do you like to use computerized board games in the next lesson? Why? 在下一堂课时，你会喜欢用电脑版桌游吗？ 为什么？	1	2	3	4	5
19.	Do you like to use computerized board games when you try to learn Science materials in the future? Why? 在往后的日子里，你会喜欢用电脑版桌游来学习科学资料吗？ 为什么？	1	2	3	4	5
20.	Would you like other teachers to use computerized board games to teach other subjects? Why? 你会希望其他老师使用电脑版桌游来教导其他科目吗？ 为什么？	1	2	3	4	5

Signature:

_____

( )

APPENDIX H: Summary of Teachers' Evaluation Form toward Interview Protocol

Date: 24.06.2022

Location: Computer Room

No.	Items	Ling Sui Ming	Koh Pei Sang	Comments
1	Tell me about yourself. 介绍一下你自己。	4	5	Should have subheadings such as Introduction, Learning Motivation, Social Interaction, and Conclusion. **Introduction:** 1, 2, 3, 4,5 1. MAINTAINED 2. Do you know how to use electronic devices and learn before? 在这之前，你知道如何使用电子设备和学习知识吗? 3.Do you enjoy learning Science before using computerized board games?
2	Do you know how to use electronic devices and learn knowledge? 你知道如何使用电子设备和学习知识吗?	4	4	
3	Do you enjoy learning Science?	4	4	

	Why? 你喜欢学习科学吗？ 为什么？			在还未使用电脑版桌游之前，你会喜欢学习科学吗? Four is almost the same as 5 (reductant). Can DELETE No. 4
4	What do you think about computerized board games? 你对电脑版桌游有什么看法?	4	4	5. MAINTAINED (No.4) **<u>Learning Motivation:</u>** 6. Do you more understand the content when you learn through computerized board games in the classroom compared with previous lesson? Why?在课堂上时学习电脑版桌游的内容，和之前的教学活动相比，你是否更加理解呢？ 为什么？(No.5)
5	Do you think computerized board games are new for you? Please give your opinion. 你认为电脑版桌游对你来说是新	5	5	7. MAINTAINED (No.6) 8. MAINTAINED (No.7) 9. MAINTAINED (No.8)

	事物吗？ 请发表你的意见。			10. MAINTAINED (No.9) 15. MAINTAINED (No.10) 16. MAINTAINED (No.11) 17. MAINTAINED (No.12) **<u>Social Interaction:</u>** 11. How often you learn Science knowledge through the implementation of educational technology like this? 你多久接触到这类的通信技术教学法来学习科学知识？(No.13) 12. MAINTAINED (No.14) 13. MAINTAINED (No.15) 14. MAINTAINED (No.16) **<u>Conclusion:</u>** 18. Do you like to use computerized board games with friends in the next
6	Do you understand the content when you learn through computerized board games in the classroom? Why? 在课堂上时通过电脑版桌游学习的内容，你是否理解？ 为什么？	5	5	
7	Do you like computerized board games to help you figure out what the Science materials are	5	5	

	about? Why? 你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗？为什么？			lesson? Why?在下一堂课，你会期待和其他同学一起用电脑版桌游吗？为什么？(No.17) 19. Do you like to use computerized board games when you try to learn Science materials with classmates in the future? Why?在往后的日子里，你会想和其他同学一块使用电脑版桌游来学习科学资料吗？为什么？(No.18) 20.MAINTAINED (No.19)
8	Do you learn a lot after using computerized board games in the classroom? Please give examples. 在课堂上玩电脑版桌游后，你会学到很多吗？请举例。	5	5	
9	Do you like using computerized	5	5	

	board games to explain the contents or answer questions? Why? 你喜欢用电脑版桌游解释内容或回答问题吗？ 为什么？			
10	Do you like to use computerized board games to list their Science materials? Why? 你喜欢用电脑版桌游列出其中的科学资料吗？ 为什么？	5	5	

11	Do you like to work individually or collaboratively? Why? 你喜欢单独还是一起进行活动？为什么？	5	5	
12	Do you like to use computerized board games with your friends? Why? 你喜欢和朋友一起玩电脑版桌游吗？ 为什么？	5	5	
13	Do you like to engage in a group activity to discuss	5	5	

	Science questions? Why? 你喜欢参加小组活动讨论科学问题吗？为什么？			
14	Do you like to communicate with other group members while you are involved in using computerized board games? Why? 在玩电脑版桌游的同时，你喜欢和其他组员交流吗？为什么？	5	5	

15	Do you relate the Science materials with the usage of computerizes board games? Why? 你是否会将科学材料与电脑版桌游的运用联系起来吗？为什么？	4	4	
16	Do you feel motivated to learn Science after implementing computerized board games? Why? 实施电脑版桌游	5	5	

	这个教学法之后，你是否有学习科学的动力？为什么?			
17	Are computerized board games different from conventional teaching methods? Why? 电脑版桌游与传统教学方法有什么不同？ 为什么?	5	5	
18	Do you like to use computerized board games in the	5	4	

	next lesson? Why? 在下一堂课时，你会喜欢用电脑版桌游吗？ 为什么？			
19	Do you like to use computerized board games when you try to learn Science materials in the future? Why? 在往后的日子里，你会喜欢用电脑版桌游来学习科学资料吗？为什么？	4	4	

20	Would you like other teachers to use computerized board games to teach other subjects? Why? 你会希望其他老师使用电脑版桌游来教导其他科目吗？为什么？	5	5	

APPENDIX I: First Draft of Pre-Test

四年级科学

Year 4 Science

前测

Pre-Test

姓名: **班级:** **分数:**

Name: _____ **Class**: _____ **Mark**: _____

时间: 1 小时

Duration: 1 hour

甲组

Section A

（60%）

指示 Instruction:

- 本文包含 60 个多项选择题。

  This paper contains 60 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

Diagram 1 shows a car driving at night.

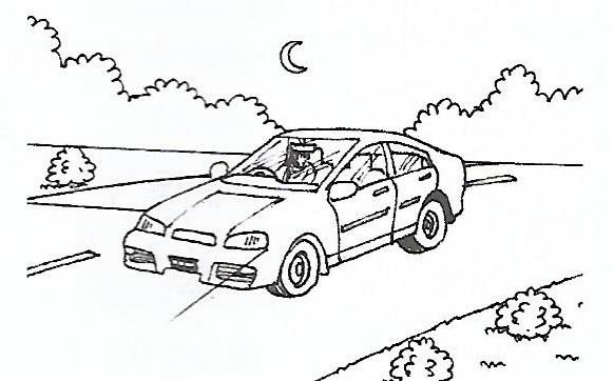


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么?

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么?

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体?

Which item is opaque?

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D 抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

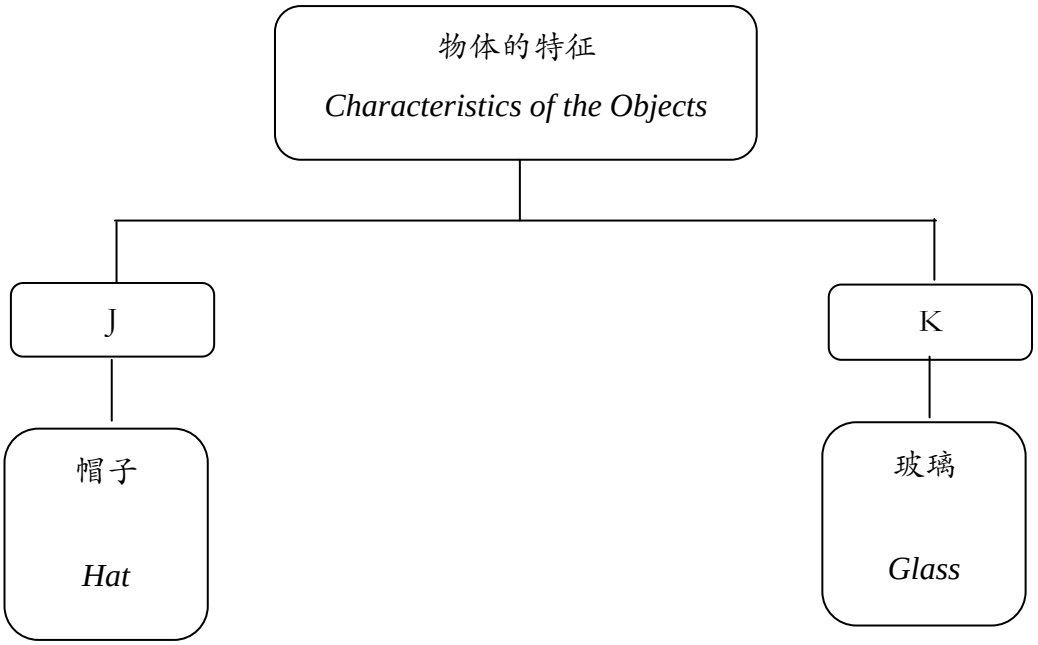


图 2

Diagram 2

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*
C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

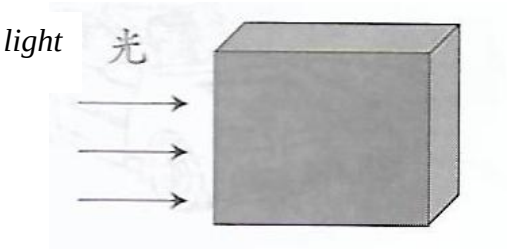


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 图 4 显示一个自然现象。

Diagram 4 shows a natural phenomenon.

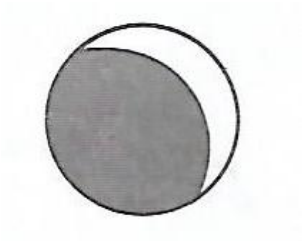


图 4

Diagram 4

哪项与图 4 的自然现象所显示的原理相同?

Which is the same principle as shown by the natural phenomenon in Diagram 4?

A 彩风用眼睛看报纸

Cai Feng reads the newspaper with her eyes

B 炫铃看着镜子来化妆

Hyun Jung looks in the mirror to put on a make-up

C 文邵看到汤匙在水中折断的现象

Wen Shao noticed the phenomenon of the spoon breaking in the water

D 善华从水面上看到鱼的位置和实际上鱼的位置不一样

The position of the fish that Shanhua sees from the water is different from the actual position of the fish

15. 下面是有关三个物体的影子的说明。

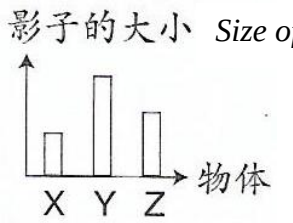
Below is an illustration of the shadows of three objects.

- 物体 X 的影子比物体 Z 的影子小。
  The shadow of object X is smaller than object Z.
- 物体 Y 的影子比物体 Z 的影子大。
  The shadow of object Y is larger than object Z.

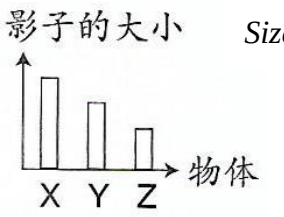
哪个条形统计图正确地显示三个影子的长度?

Which bar chart shows the length of the three shadows correctly?

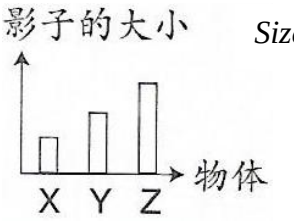
A



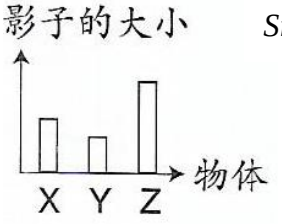
B



C



D



16. 什么是光的折射?

What is refraction of light?

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

17. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

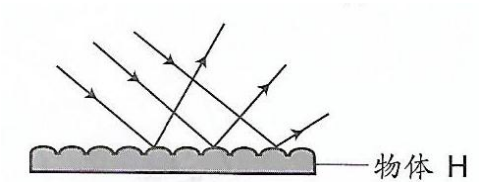


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

18. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

19. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

20. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

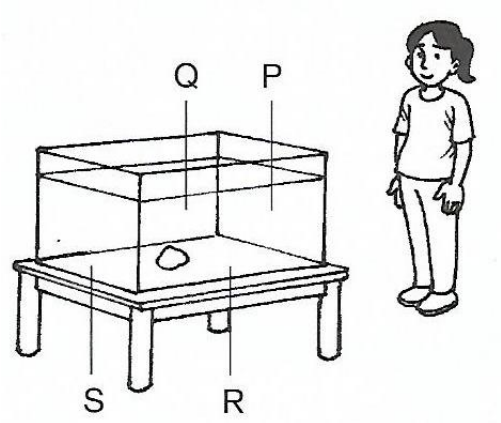


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置？

Which is the position of the stone observed by Shi Qi from the water?

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

Diagram 1 shows a source of energy.

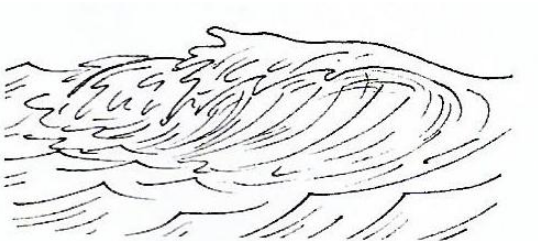


图 1

Diagram 1

哪项是图 1 的能的来源?

Which one is the source of the energy in Diagram 1?

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

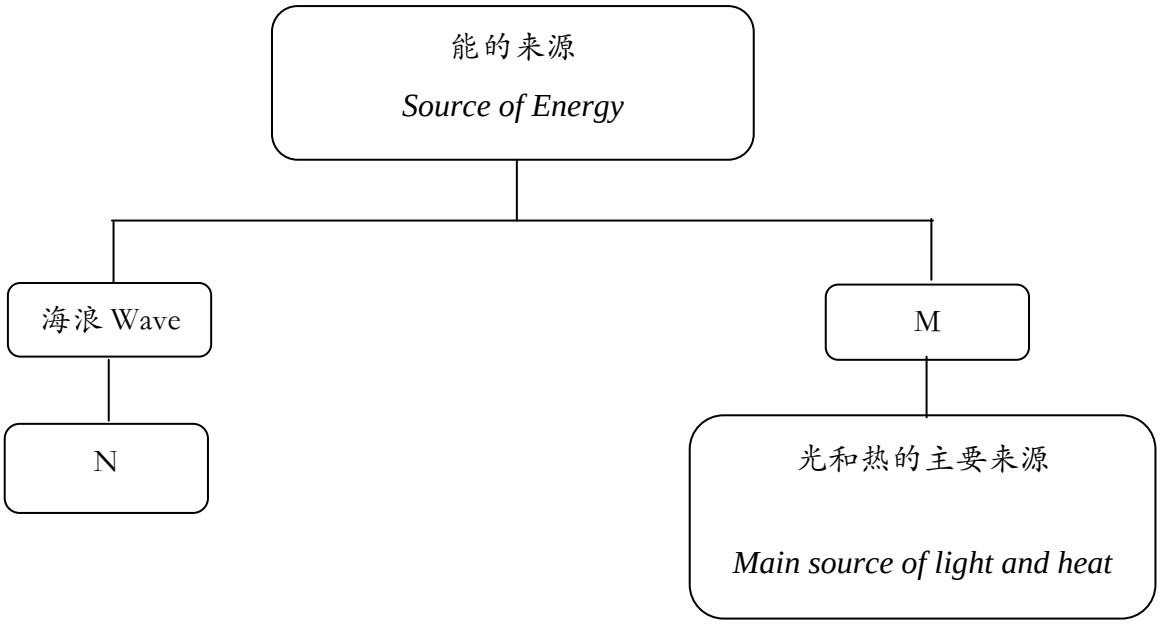


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

	M	**N**
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

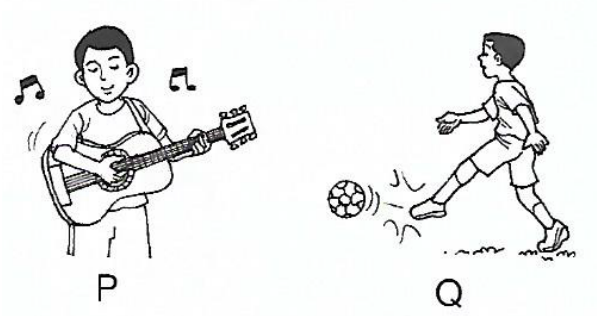


图 3

Diagram 3

活动 P 和活动 Q 具备什么能?

What kind of energy Activity P and Activity Q have?

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

A 热能

Heat energy

B 声能

Sound energy

C 动能

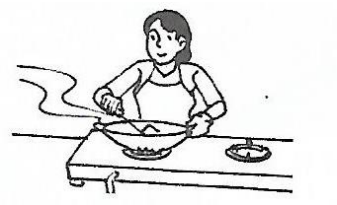
Kinetic energy

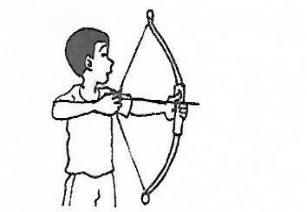
D 势能

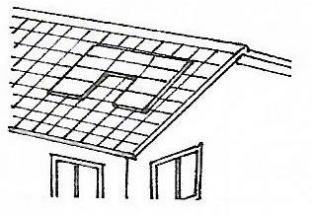
Potential energy

6. 哪个活动具备势能？

Which activity possess potential energy?

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

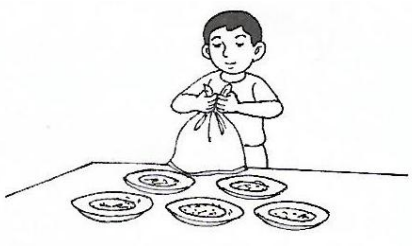


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

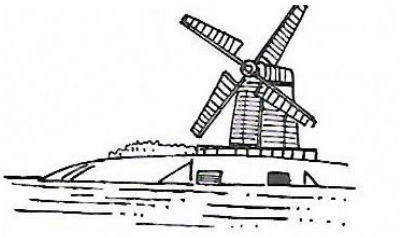
There is only one type of energy

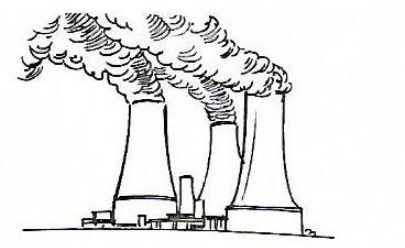
D 能可从一种形式转换至另一种形式或多种形式

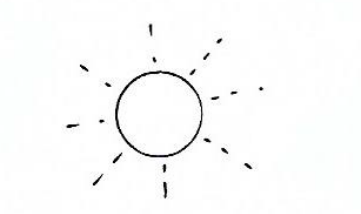
Energy can be transformed from one type to another or multiple types of energy

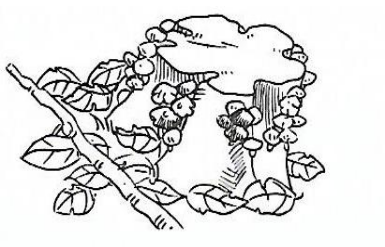
12. 哪项是不可更新的能源?

Which one is non-renewable energy?

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

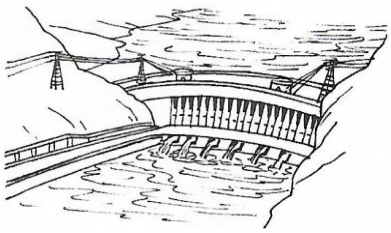


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

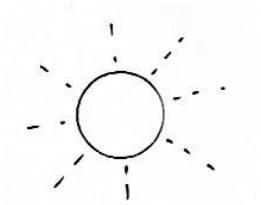


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

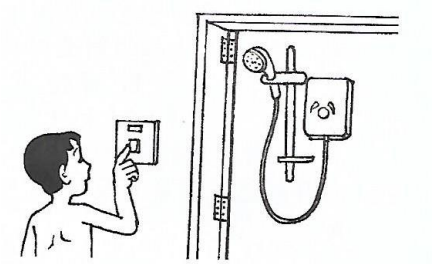


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

> 矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。
>
> *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

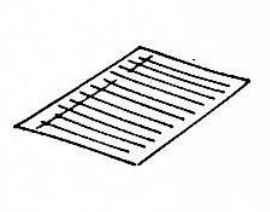
D 木材

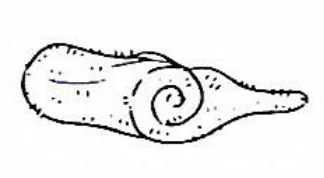
Wood

2. 哪种物品是用丝来制造?

Which item is made of silk?

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

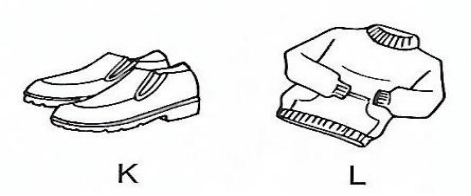


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

A P 和 Q

P and Q

B P 和 R

P and R

C　Q 和 R

Q and R

D　R 和 S

R and S

5.　图 3 显示一个分类图。

Figure 3 shows a classification diagram.

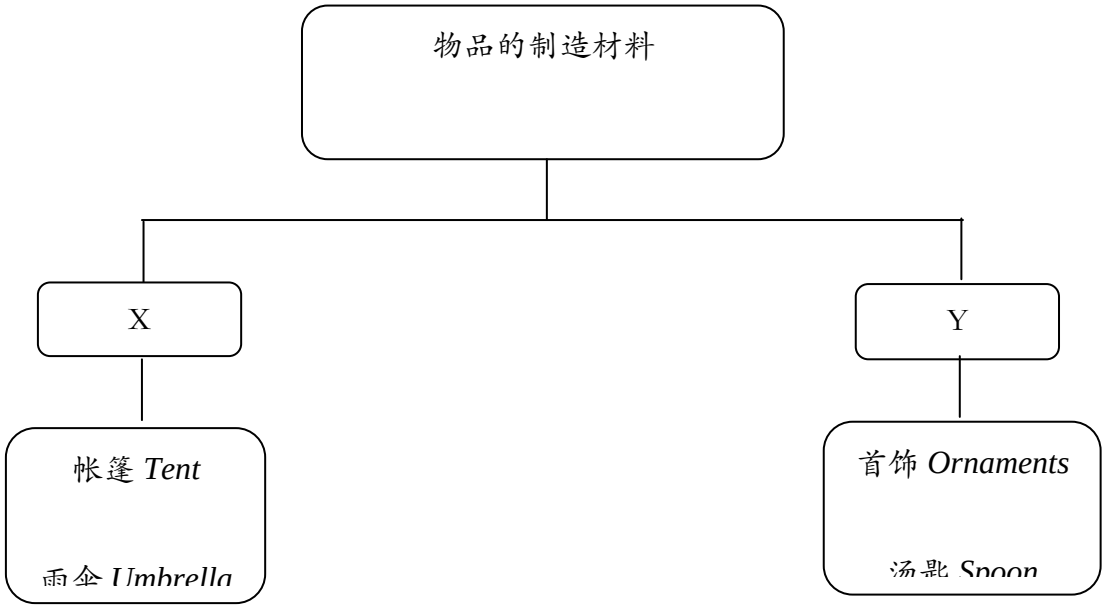


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

	X	**Y**
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革	塑料

	Leather	*Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

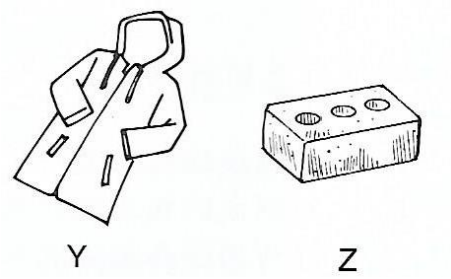


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

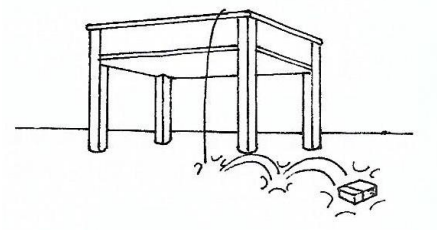


图 7

Diagram 7

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮擦电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片	回形针

	Blade	*Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

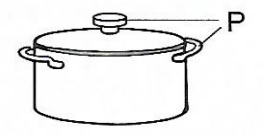


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.

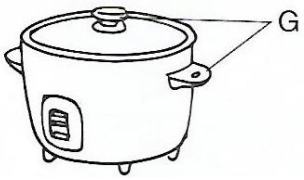


图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

   Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

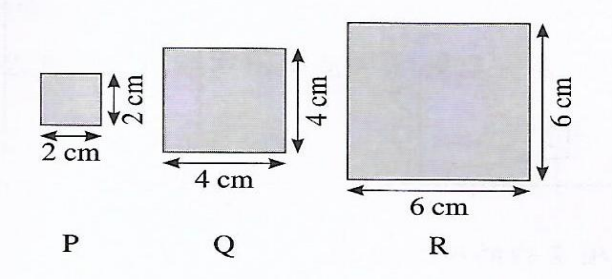


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

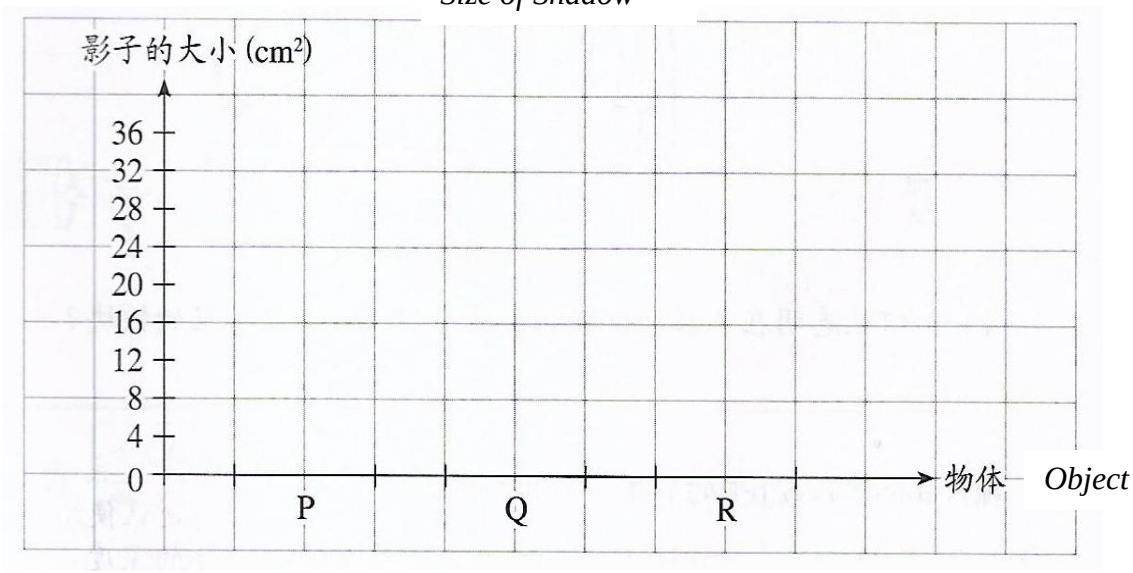
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。

Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

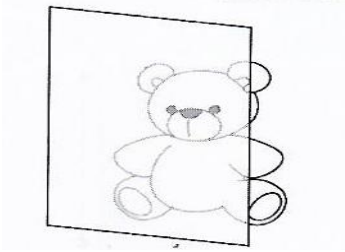
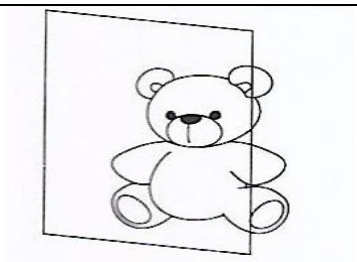
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

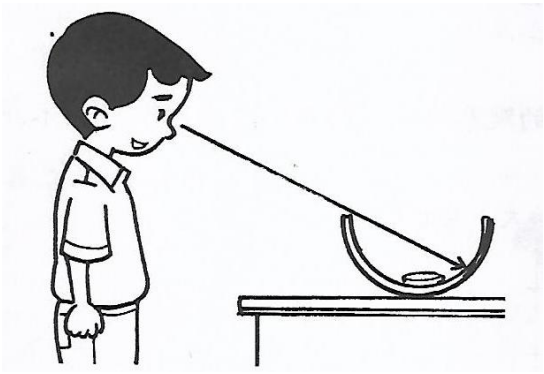


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

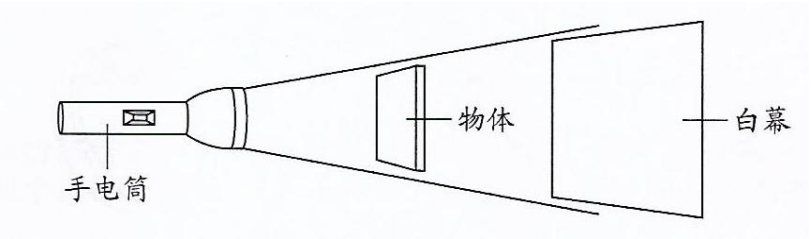


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

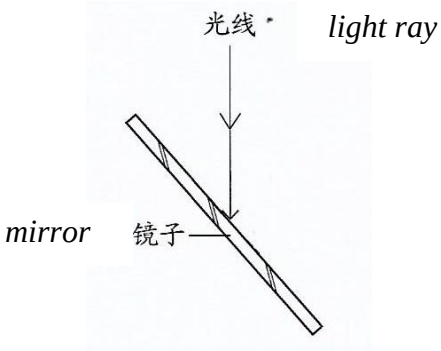


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

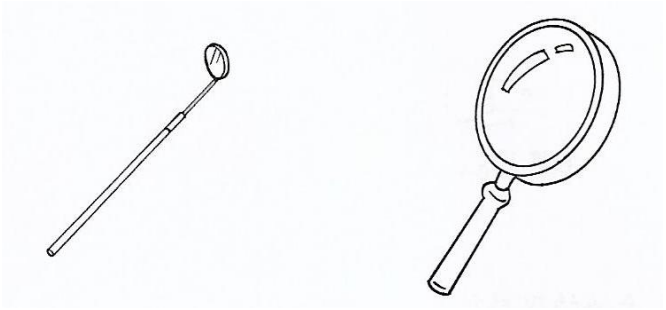


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

i. 口腔镜：_____

Dental mirror: _____

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

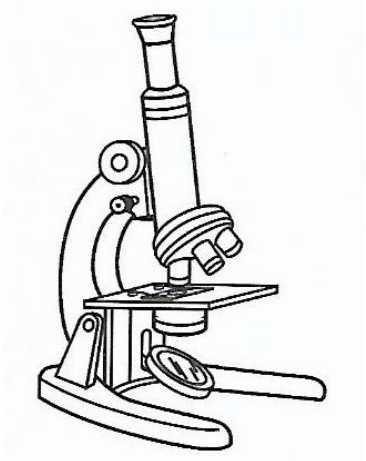


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

【2分】

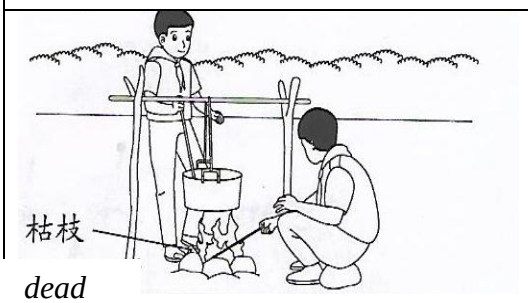
[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

S 组 *Team S*	T 组 *Team T*
	

dead branches

natural

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

i. S 组：_____

Team S: _____

ii. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

【 2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源？

Which energy source would you encourage them to use?

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

_____

【1分】

[1 mark]

2.

a) 什么是能？

What is energy?

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

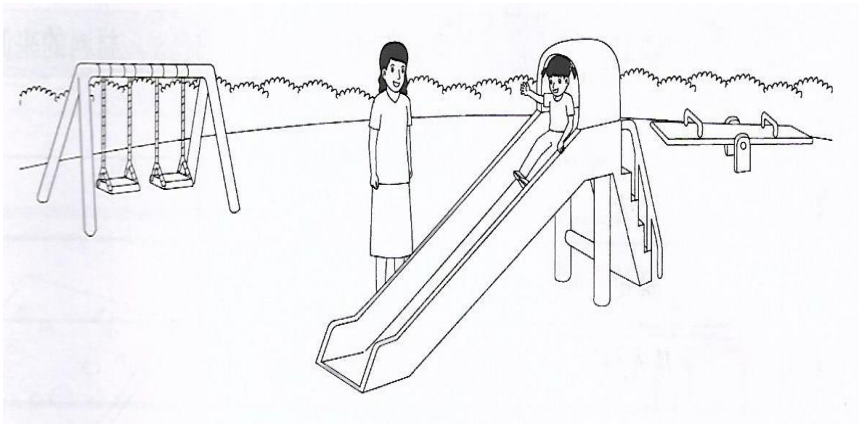


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能？

What kind of energy does my sister have on the slide?

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能

Electrical energy ⟶ *Light energy + Sound energy*

X电器是什么?

What is *appliance X*?

_____

【2分】

[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

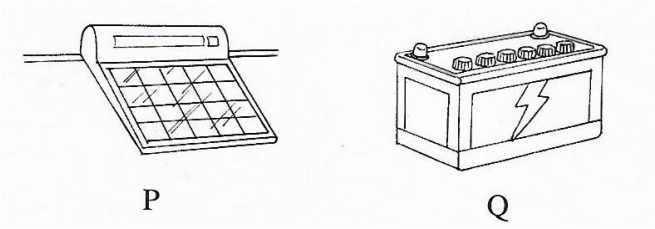


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

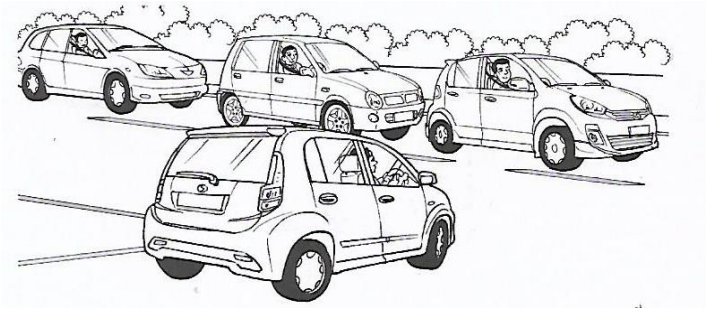


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

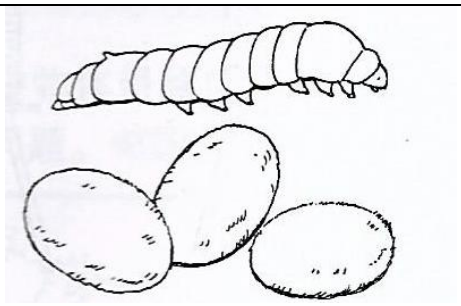
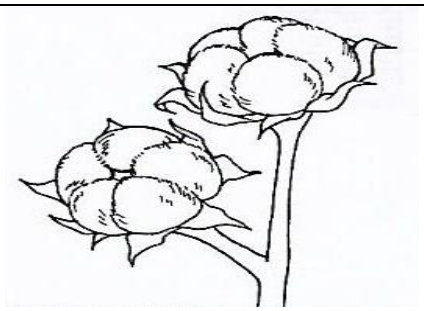
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

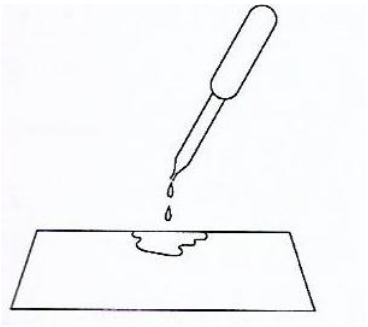
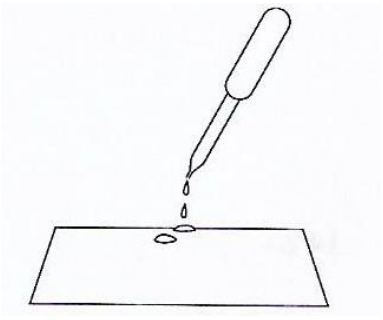
i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

【2 分】

[2 marks]

b) 根据你在（a）项的答案，把水滴在P材料和Q材料上，它们的观察结果是怎样的？填写正确的答案。

Based on the energy formation, what kind of energy it is?

i)	ii)
	
_____ 材料 *Material* _____	_____ 材料 *Material* _____

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶？

Which material is suitable for dealing with overturned milk on the table?

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

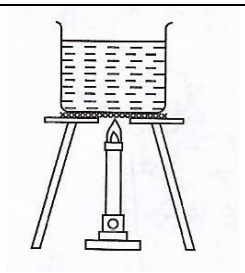
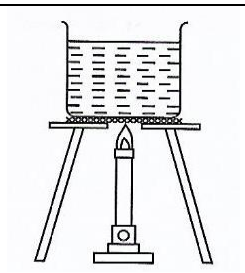
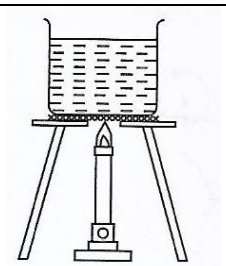
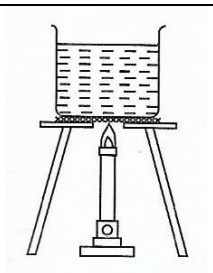
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

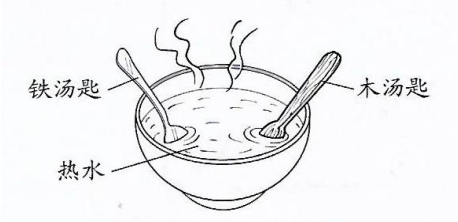


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

_____

【2 分】

[2 marks]

ii. 五分钟后，用手轻轻触摸铁汤匙和木汤匙。

After 5 minutes, lightly touch the iron spoon and wooden spoon with hands.

哪项观察是正确的？画 (/)。

Which observation is correct? Pick (/).

	铁汤匙比木汤匙热 *Iron spoon is hotter than wooden spoon.*
	木汤匙比铁汤匙热 *Wooden spoon is hotter than iron spoon.*
	铁汤匙是热的，木汤匙不热 *Iron spoon is hot, wooden spoon is not.*

【1 分】

[1 mark]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

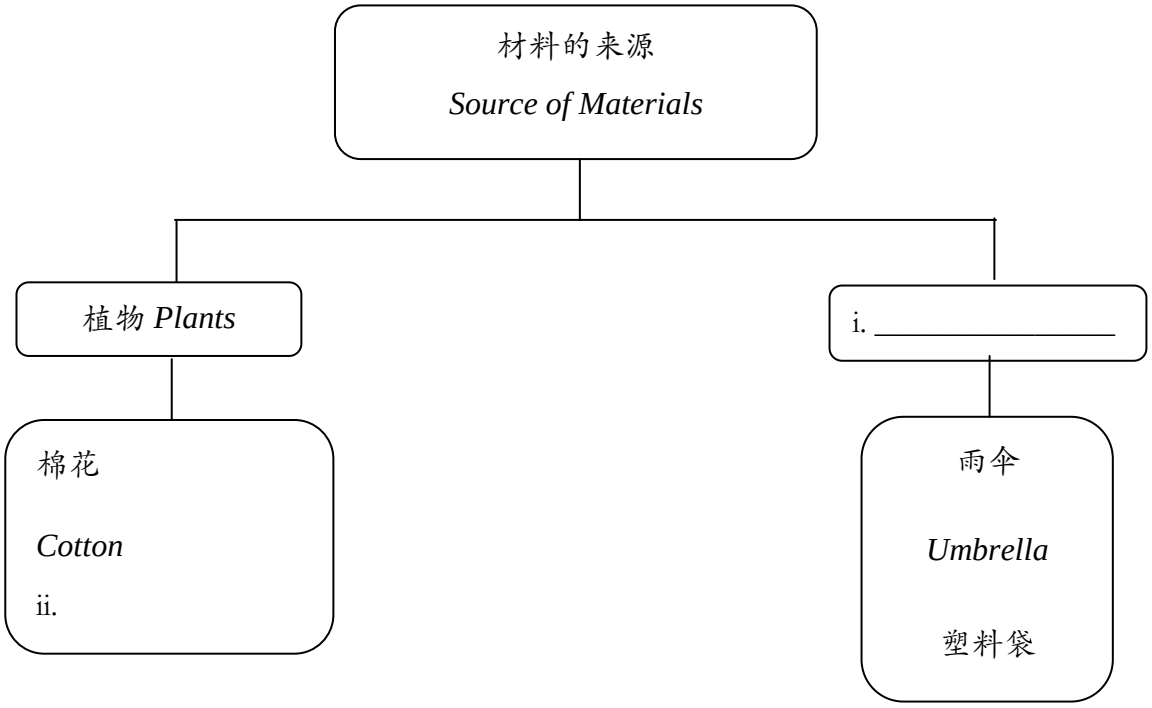


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

1. 能看到宠物在屋子里的情况。

   Can see the pet in the house.

2. 宠物在屋子里不会日晒雨淋。

   The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

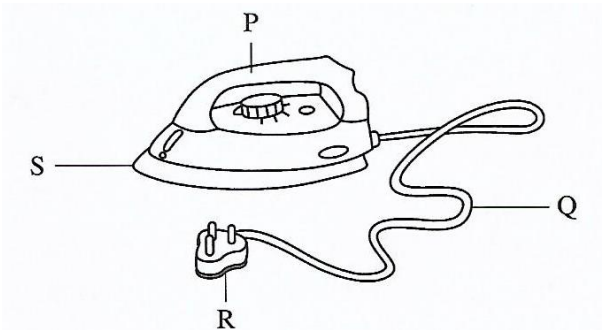


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

_____

【1 分】

[2 marks]

APPENDIX J: First Draft of Post-Test

四年级科学

Year 4 Science

前测

Post-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

甲组

Section A

（60%）

<u>指示 Instruction:</u>

- 本文包含 60 个多项选择题。

  This paper contains 60 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

   Diagram 1 shows a car driving at night.

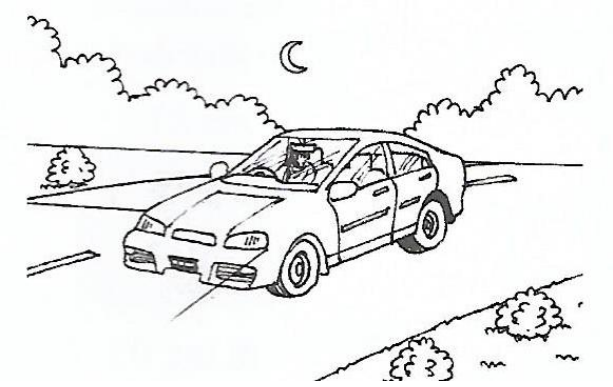


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么?

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么?

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体?

Which item is opaque?

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D 抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

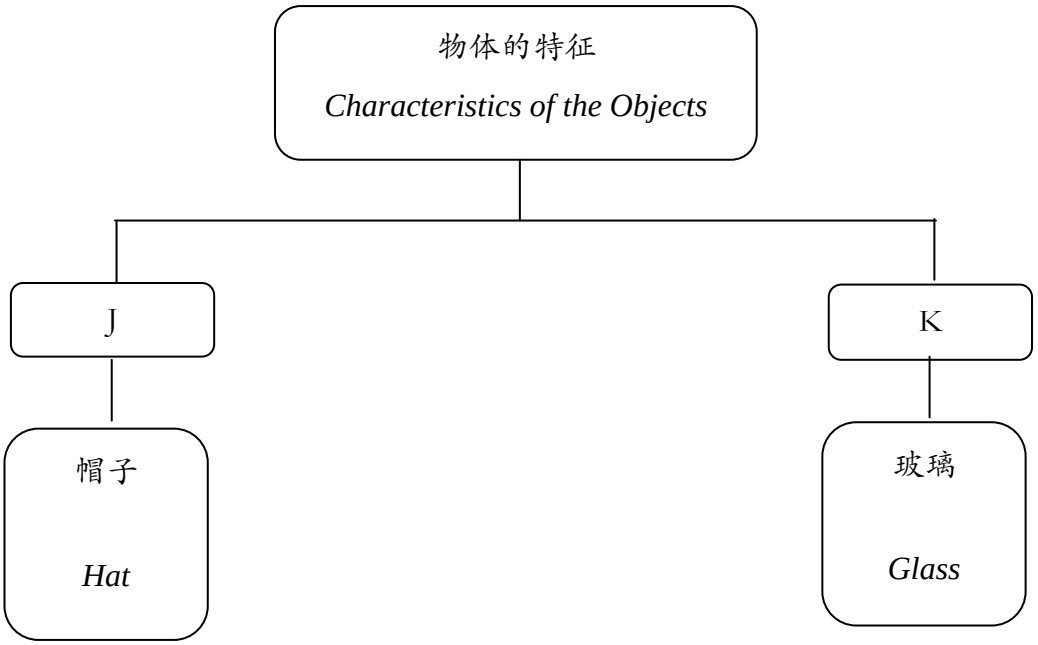


图 2

Diagram 2

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*
C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

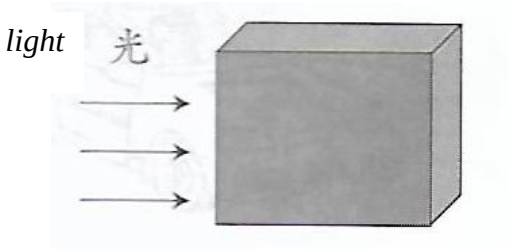


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 图 4 显示一个自然现象。

Diagram 4 shows a natural phenomenon.

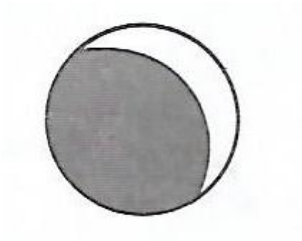


图 4

Diagram 4

哪项与图 4 的自然现象所显示的原理相同?

Which is the same principle as shown by the natural phenomenon in Diagram 4?

A 彩风用眼睛看报纸

Cai Feng reads the newspaper with her eyes

B 炫铃看着镜子来化妆

Hyun Jung looks in the mirror to put on a make-up

C 文邵看到汤匙在水中折断的现象

Wen Shao noticed the phenomenon of the spoon breaking in the water

D 善华从水面上看到鱼的位置和实际上鱼的位置不一样

The position of the fish that Shanhua sees from the water is different from the actual position of the fish

15. 下面是有关三个物体的影子的说明。

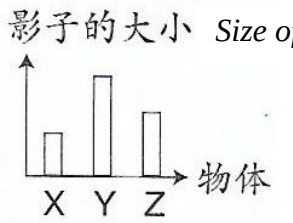
Below is an illustration of the shadows of three objects.

- 物体 X 的影子比物体 Z 的影子小。
  The shadow of object X is smaller than object Z.
- 物体 Y 的影子比物体 Z 的影子大。
  The shadow of object Y is larger than object Z.

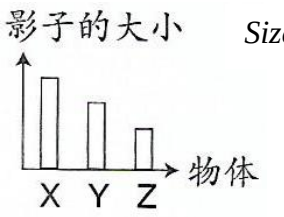
哪个条形统计图正确地显示三个影子的长度?

Which bar chart shows the length of the three shadows correctly?

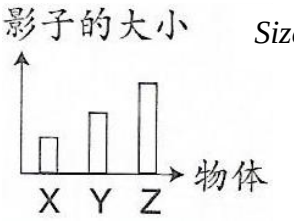
A



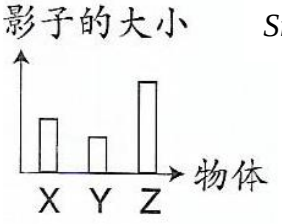
B



C



D



16. 什么是光的折射?

What is refraction of light?

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

17. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

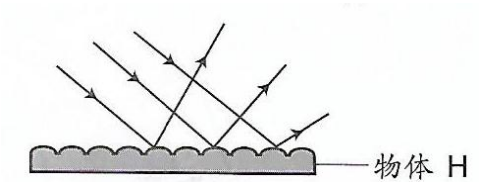


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

18. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

19. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

20. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

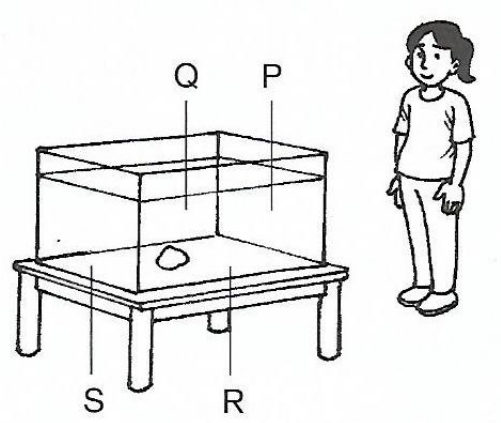


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置？

Which is the position of the stone observed by Shi Qi from the water?

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

   Diagram 1 shows a source of energy.

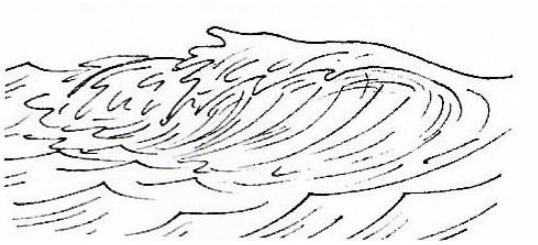


图 1

Diagram 1

哪项是图 1 的能的来源?

Which one is the source of the energy in Diagram 1?

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

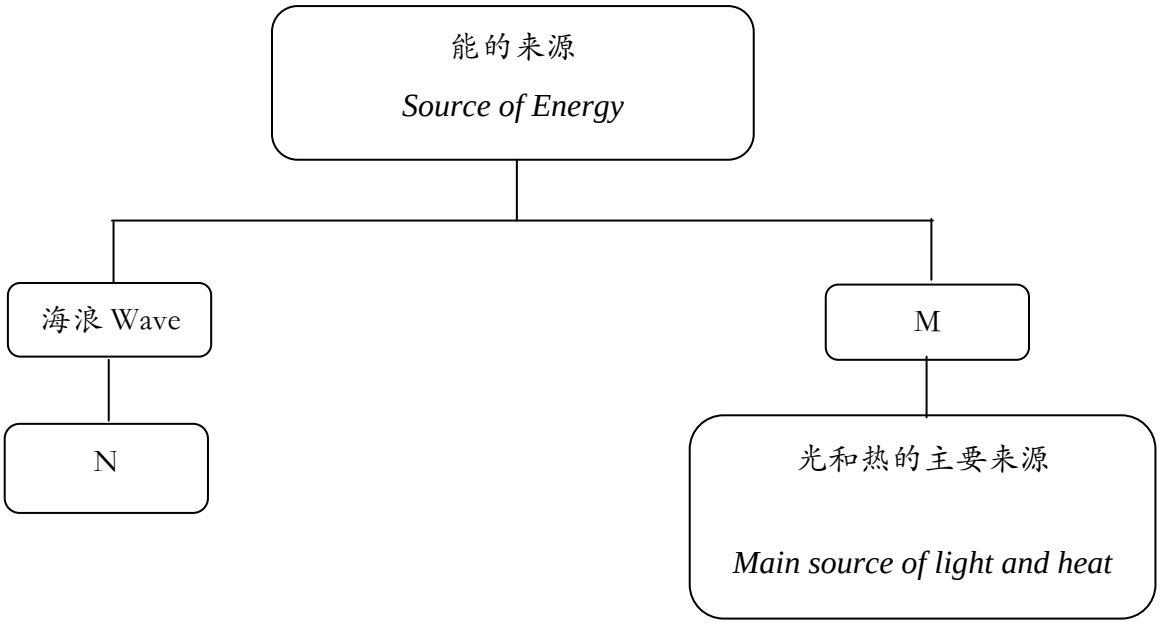


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

	M	**N**
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

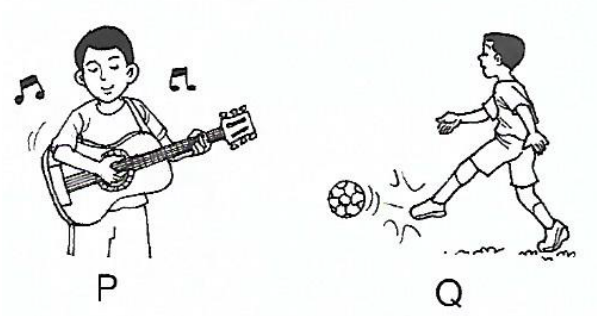


图 3

Diagram 3

活动 P 和活动 Q 具备什么能?

What kind of energy Activity P and Activity Q have?

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

A 热能

Heat energy

B 声能

Sound energy

C 动能

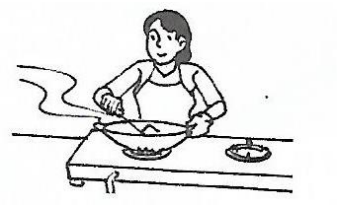
Kinetic energy

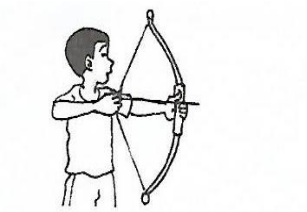
D 势能

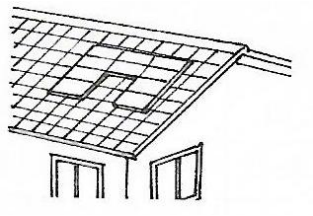
Potential energy

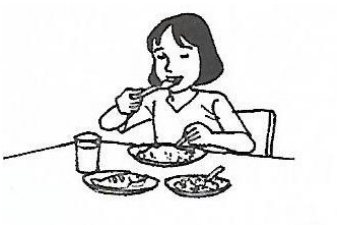
6. 哪个活动具备势能？

Which activity possess potential energy?

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

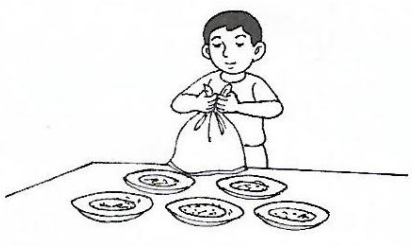


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

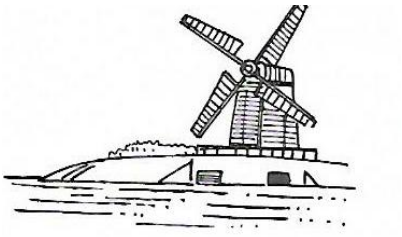
There is only one type of energy

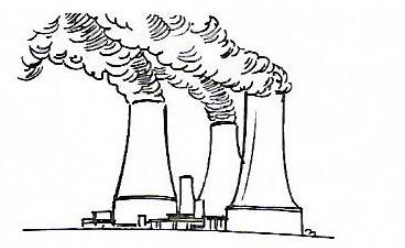
D 能可从一种形式转换至另一种形式或多种形式

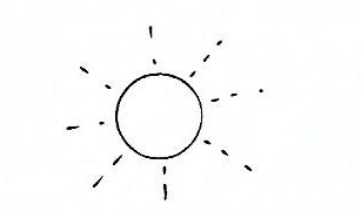
Energy can be transformed from one type to another or multiple types of energy

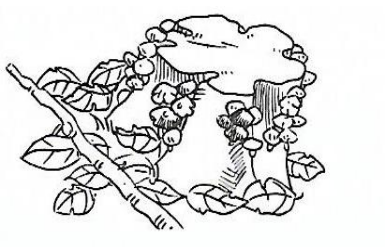
12. 哪项是不可更新的能源?

Which one is non-renewable energy?

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

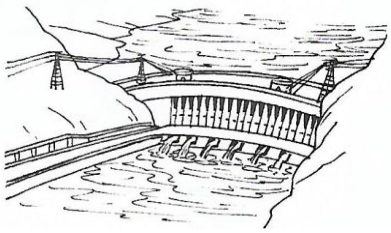


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

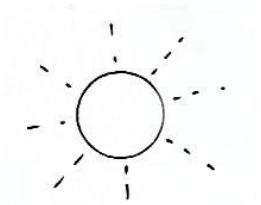


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

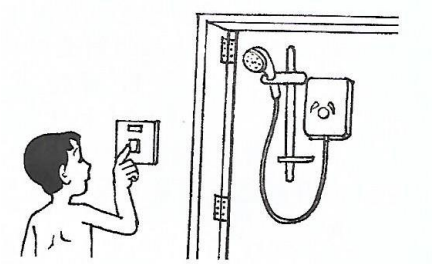


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

> 矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。
>
> *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

   Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

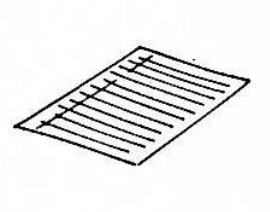
D 木材

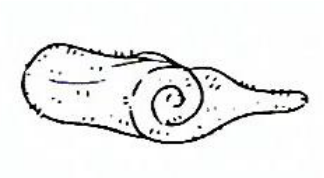
Wood

2. 哪种物品是用丝来制造?

Which item is made of silk?

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

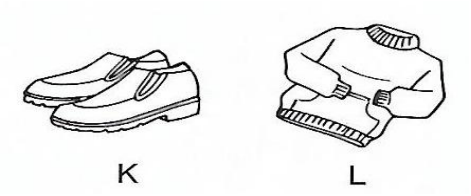


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

A P 和 Q

P and Q

B P 和 R

P and R

C　Q 和 R

Q and R

D　R 和 S

R and S

5.　图 3 显示一个分类图。

Figure 3 shows a classification diagram.

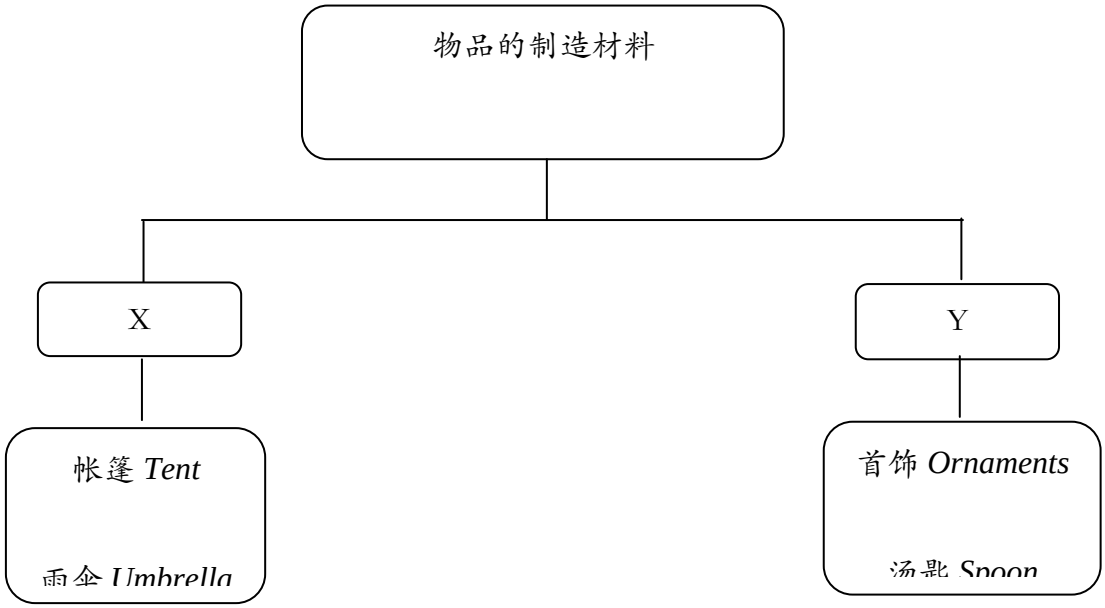


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

	X	**Y**
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革	塑料

	Leather	*Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

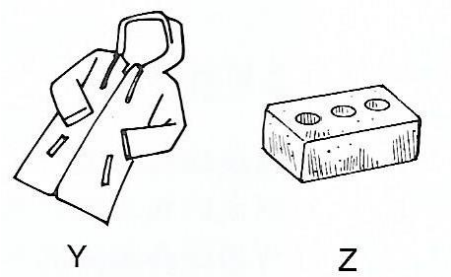


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

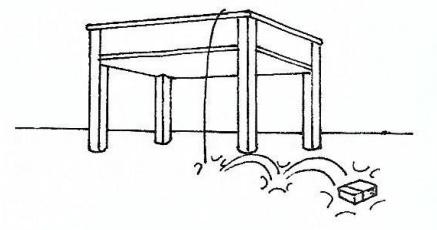


图 7

Diagram 7

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮擦电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片	回形针

	Blade	*Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

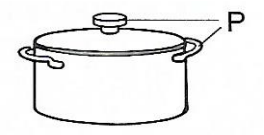


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.

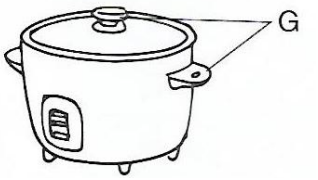


图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

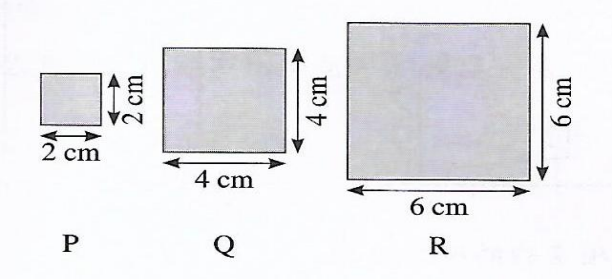


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

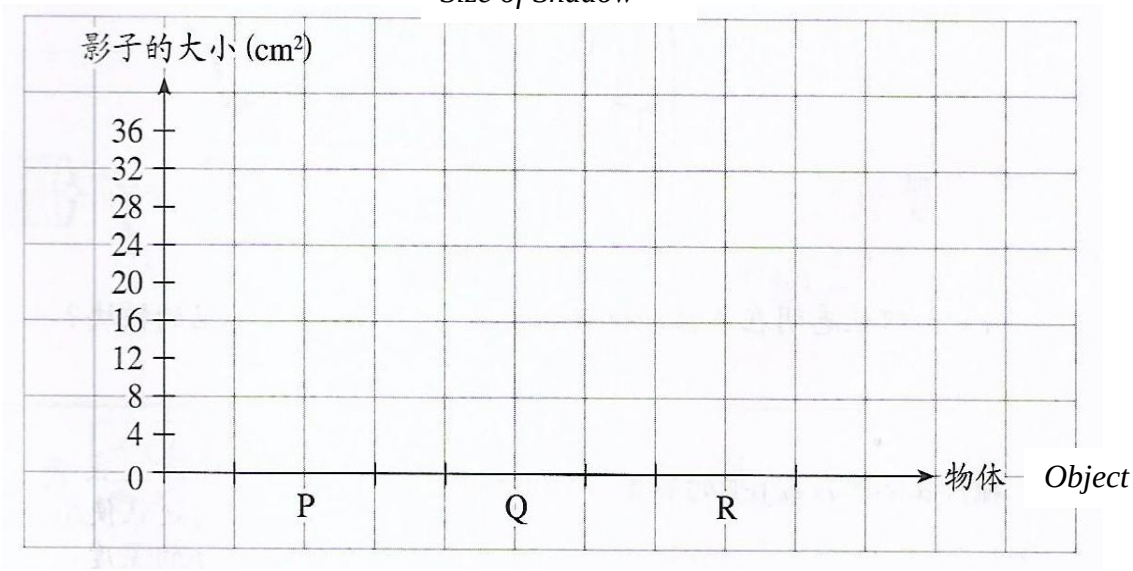
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。

Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

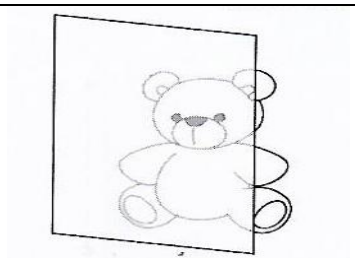
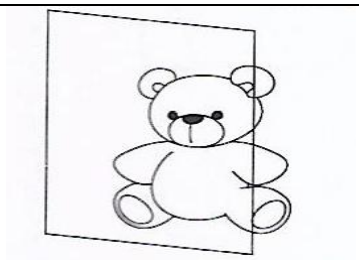
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

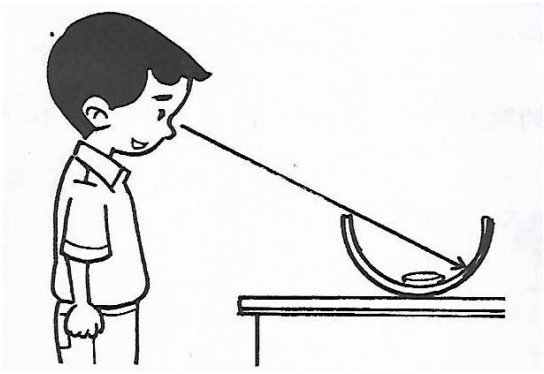


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

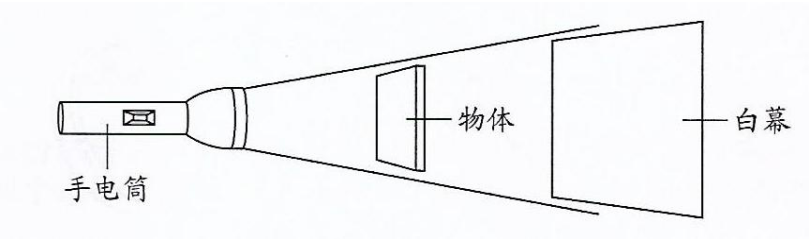


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

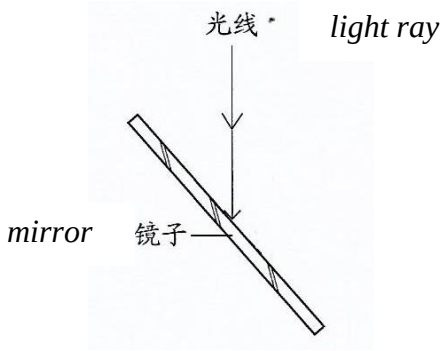


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

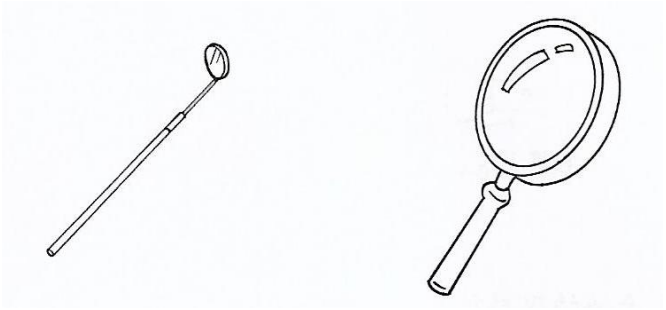


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

i. 口腔镜：_____

Dental mirror: _____

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

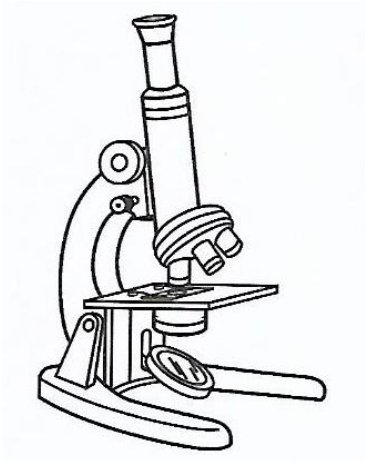


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

【2分】

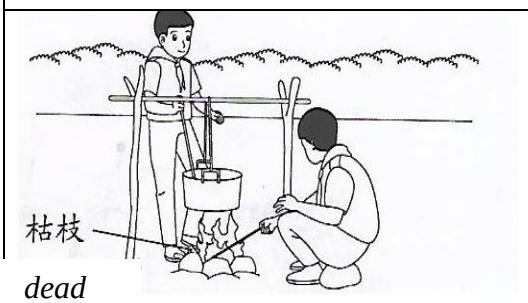
[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

S 组 *Team S*	T 组 *Team T*
	

dead

natural

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

iii. S 组：_____

Team S: _____

iv. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

【 2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源？

Which energy source would you encourage them to use?

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

_____

【1分】

[1 mark]

2.

a) 什么是能？

What is energy?

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

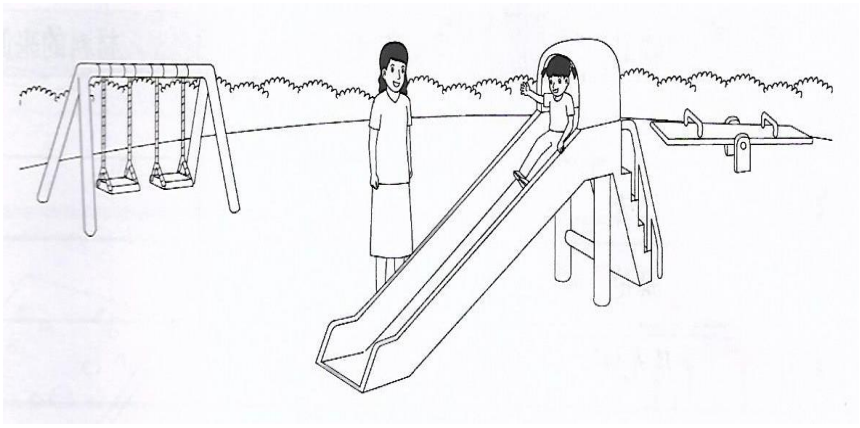


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能？

What kind of energy does my sister have on the slide?

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能

Electrical energy ⟶ *Light energy + Sound energy*

X电器是什么?

What is *appliance X*?

_____

【2分】

[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

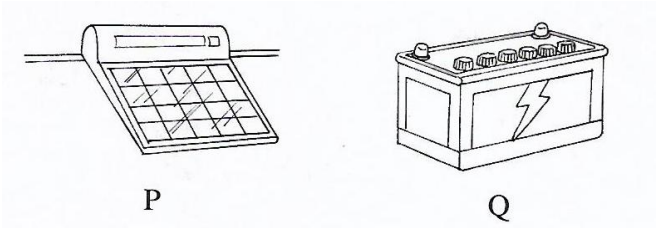


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

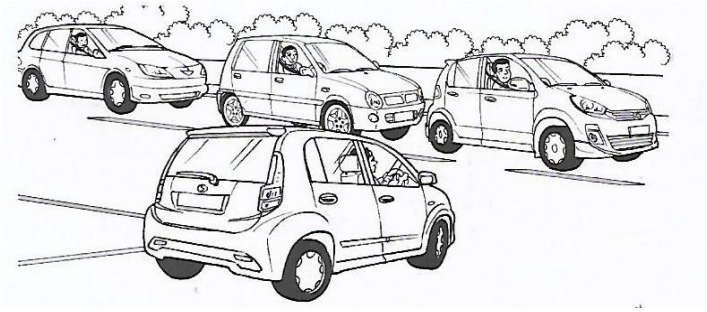


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

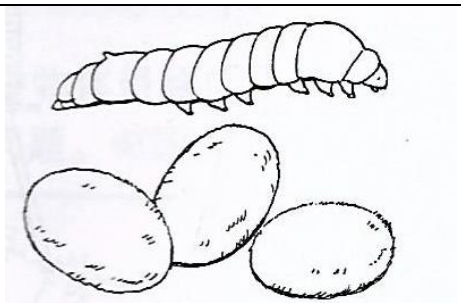
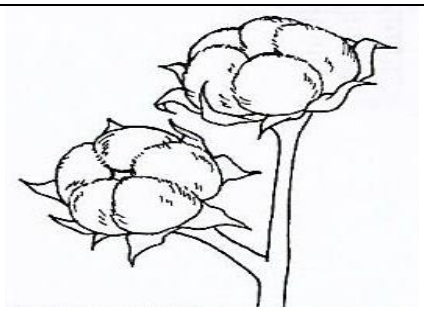
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

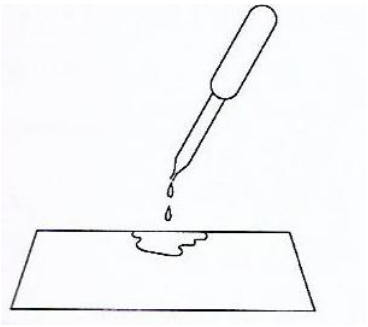
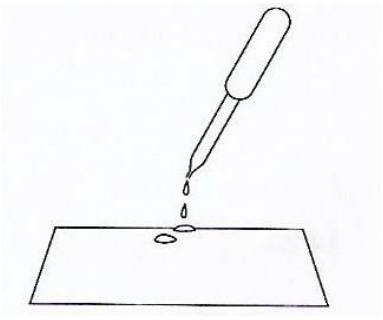
i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

【2 分】

[2 marks]

b) 根据你在（a）项的答案，把水滴在P材料和Q材料上，它们的观察结果是怎样的？填写正确的答案。

Based on the energy formation, what kind of energy it is?

i)	ii)
	
_____ 材料 *Material* _____	_____ 材料 *Material* _____

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶？

Which material is suitable for dealing with overturned milk on the table?

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

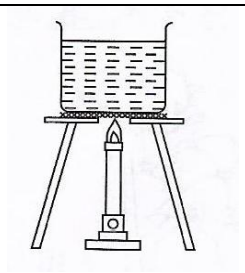
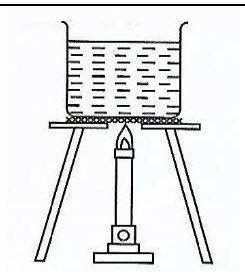
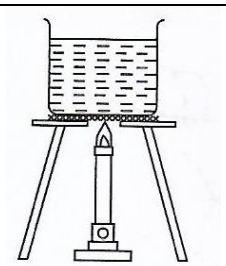
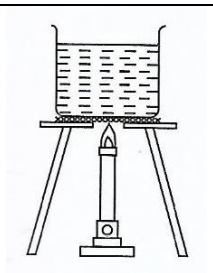
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

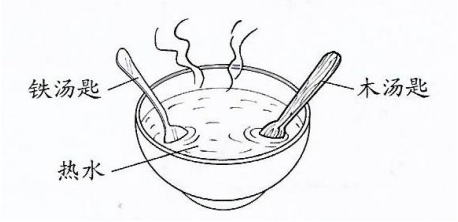


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

_____

【2 分】

[2 marks]

ii. 五分钟后，用手轻轻触摸铁汤匙和木汤匙。

After 5 minutes, lightly touch the iron spoon and wooden spoon with hands.

哪项观察是正确的？画 (/)。

Which observation is correct? Pick (/).

	铁汤匙比木汤匙热 *Iron spoon is hotter than wooden spoon.*
	木汤匙比铁汤匙热 *Wooden spoon is hotter than iron spoon.*
	铁汤匙是热的，木汤匙不热 *Iron spoon is hot, wooden spoon is not.*

【1 分】

[1 mark]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

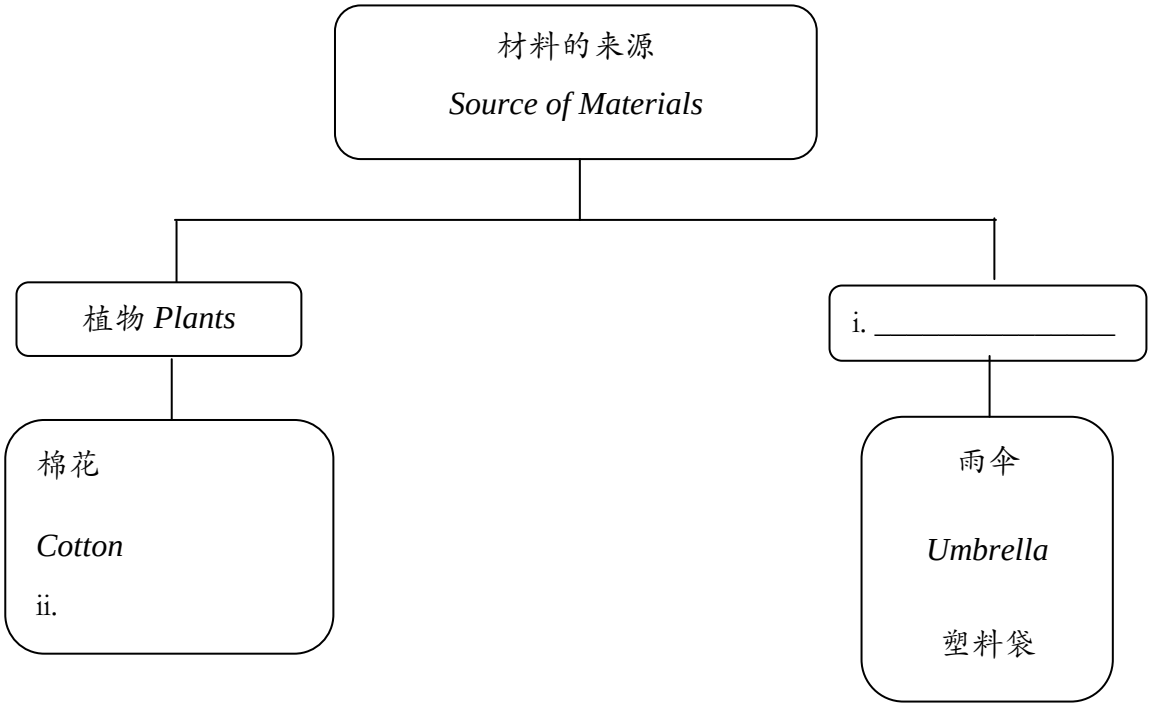


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

3. 能看到宠物在屋子里的情况。

   Can see the pet in the house.

4. 宠物在屋子里不会日晒雨淋。

   The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

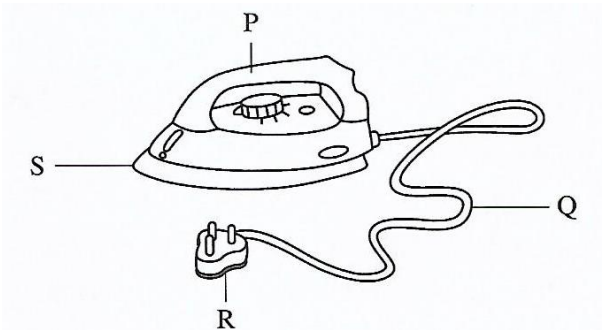


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

_____

【1 分】

[2 marks]

APPENDIX K: Second Draft of Pre-Test

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

甲组

Section A

（60%）

<u>指示 Instruction:</u>

- 本文包含 60 个多项选择题。

  This paper contains 60 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

   Diagram 1 shows a car driving at night.

5.1/LS5.1.1/PS4

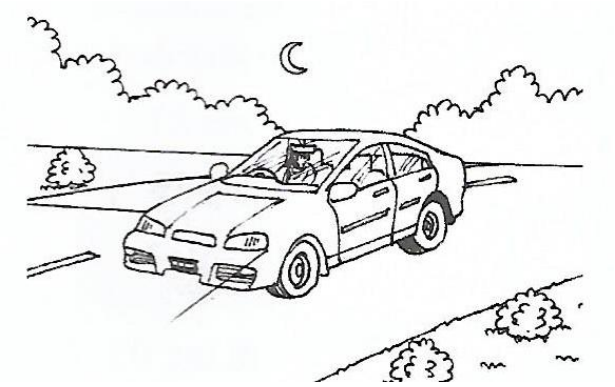


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么？

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

5.1/LS5.1.1/PS4

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

5.1/LS5.1.2/PS5 (HOTs)

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么？

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

5.1/LS5.1.3/PS5 (HOTs)

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体?

Which item is opaque?

5.1/LS5.1.2/PS1

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D 抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

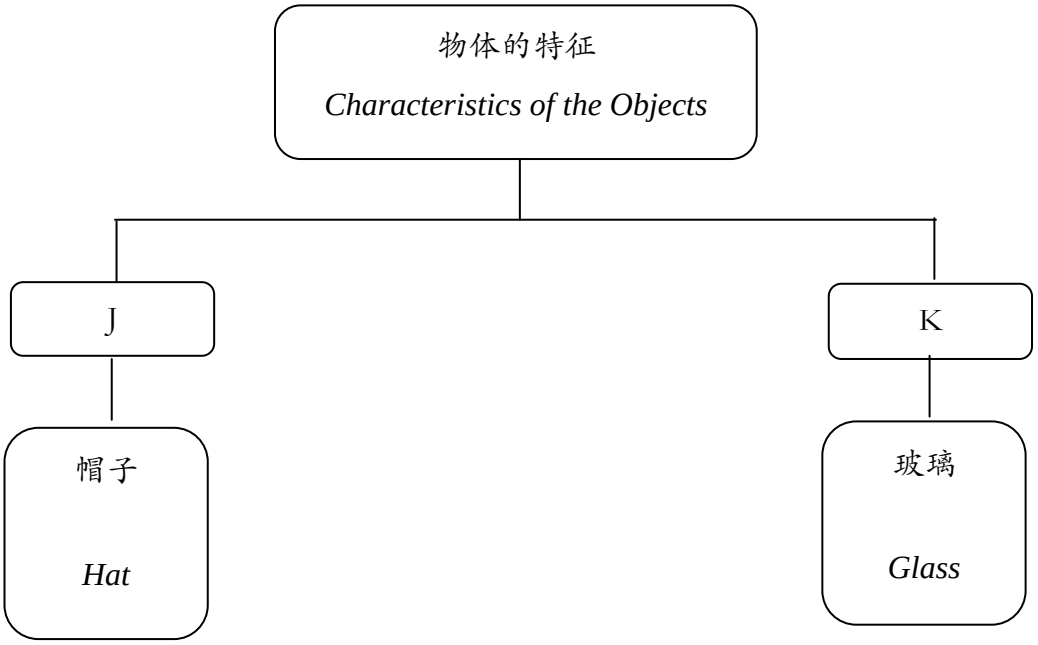


图 2

Diagram 2

5.1/LS5.1.2/PS3

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*

C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

5.1/LS5.1.4/PS5 (HOTs)

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

5.1/LS5.1.3/PS5 (HOTs)

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

5.1/LS5.1.3/PS5 (HOTs)

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

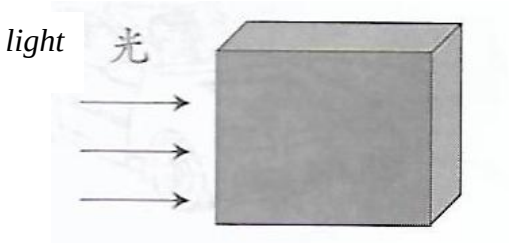


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

5.1/LS5.1.3/PS5 (HOTs)

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

5.1/LS5.1.4/PS5 (HOTs)

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 图 4 显示一个自然现象。

Diagram 4 shows a natural phenomenon.

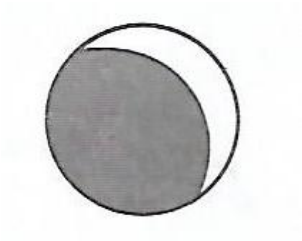


图 4

Diagram 4

哪项与图 4 的自然现象所显示的原理相同?

Which is the same principle as shown by the natural phenomenon in Diagram 4?

5.1/LS5.2.2/PS3

A 彩风用眼睛看报纸

Cai Feng reads the newspaper with her eyes

B 炫铃看着镜子来化妆

Hyun Jung looks in the mirror to put on a make-up

C 文邵看到汤匙在水中折断的现象

Wen Shao noticed the phenomenon of the spoon breaking in the water

D 善华从水面上看到鱼的位置和实际上鱼的位置不一样

The position of the fish that Shanhua sees from the water is different from the actual position of the fish

15. 下面是有关三个物体的影子的说明。

Below is an illustration of the shadows of three objects.

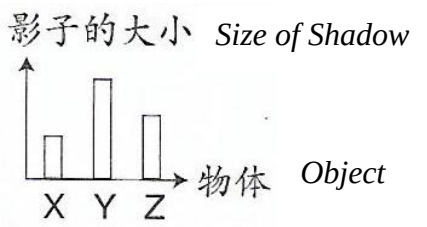
- 物体 X 的影子比物体 Z 的影子小。
  The shadow of object X is smaller than object Z.
- 物体 Y 的影子比物体 Z 的影子大。
  The shadow of object Y is larger than object Z.

哪个条形统计图正确地显示三个影子的长度?

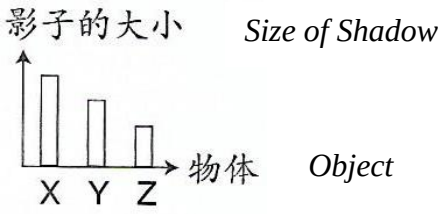
Which bar chart shows the length of the three shadows correctly?

5.1/LS5.1.3/PS5 (HOTs)

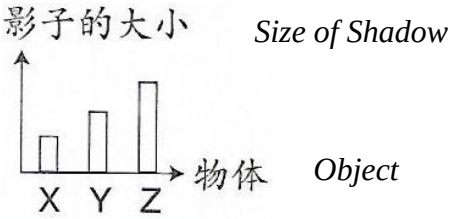
A



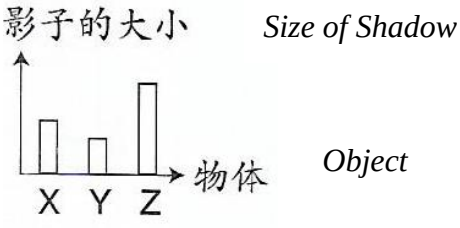
B



C



D



16. 什么是光的折射?

What is refraction of light?

5.3/LS5.3.1/PS1

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

17. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

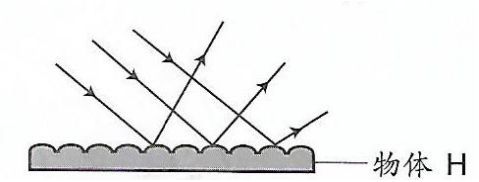


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

5.2/LS5.2.2/PS3

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

18. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

5.3/LS5.3.2/PS4

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

19. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

5.2/LS5.3.2/PS4

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

20. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

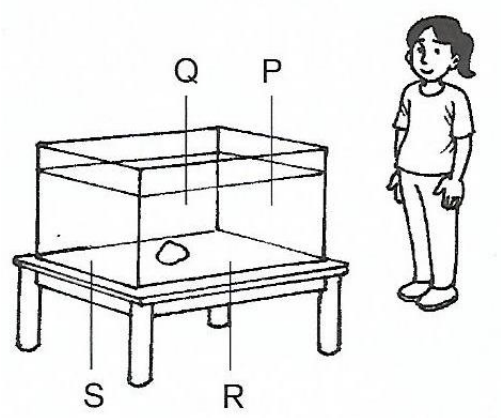


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置?

Which is the position of the stone observed by Shi Qi from the water?

5.3/LS5.3.2/PS4

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

   Diagram 1 shows a source of energy.

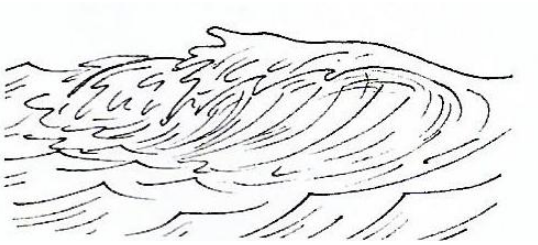


图 1

Diagram 1

哪项是图 1 的能的来源？

Which one is the source of the energy in Diagram 1?

7.1/LS7.1.2/PS1

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

7.1/LS7.1.2/PS2

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

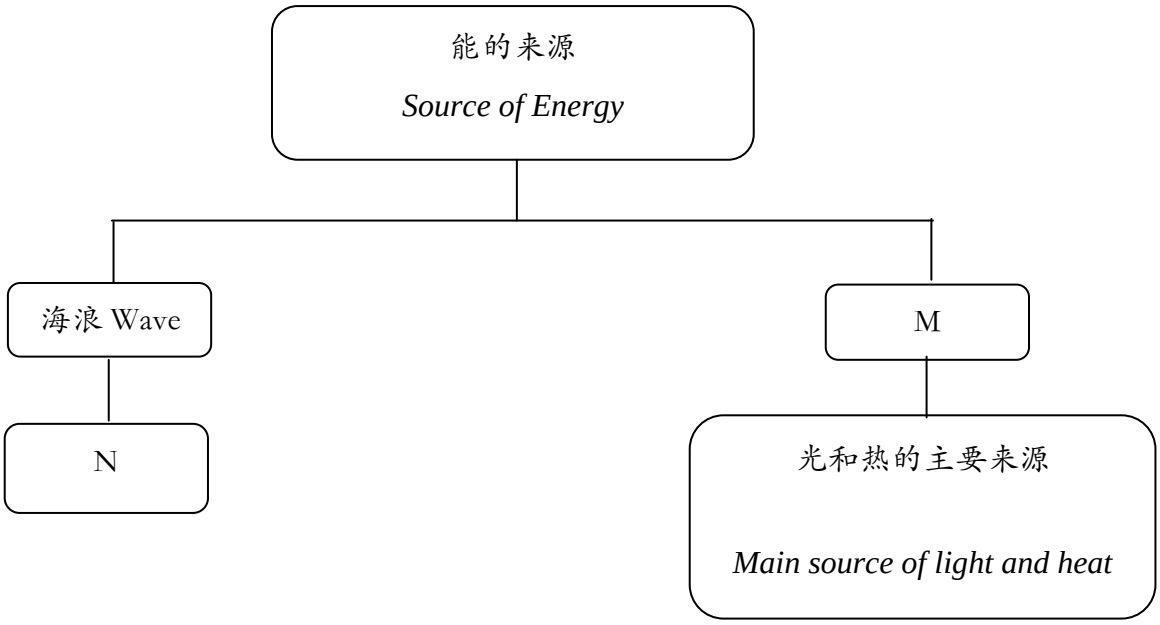


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

7.1/LS7.1.2/PS4

	M	N
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

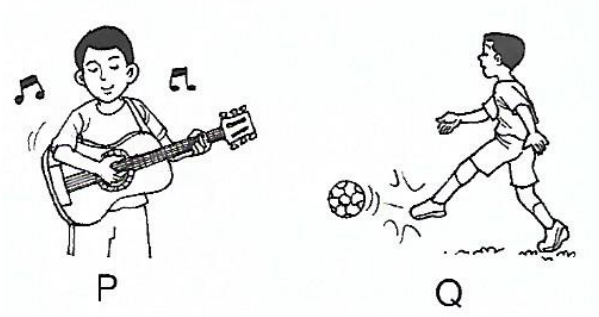


图 3

Diagram 3

活动 P 和活动 Q 具备什么能?

What kind of energy Activity P and Activity Q have?

7.1/LS7.1.4/PS1

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

7.1/LS7.1.3/PS1

A 热能

Heat energy

B 声能

Sound energy

C 动能

Kinetic energy

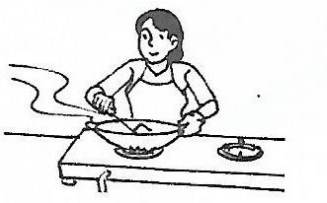
D 势能

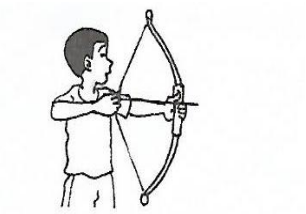
Potential energy

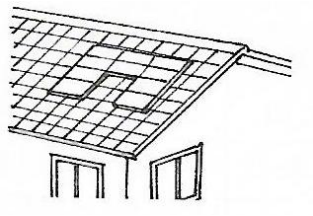
6. 哪个活动具备势能？

Which activity possess potential energy?

7.1/LS7.1.3/PS1

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

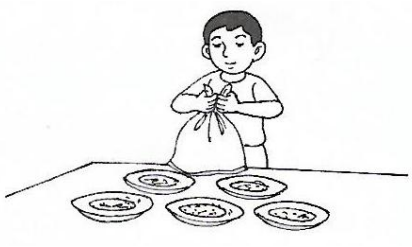


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

7.1/LS7.1.2/PS2

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

7.1/LS7.1.4/PS3

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

7.1/LS7.1.4/PS5 (HOTs)

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

7.1/LS7.1.4/PS5 (HOTs)

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

7.1/LS7.1.5/PS5 (HOTs)

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

There is only one type of energy

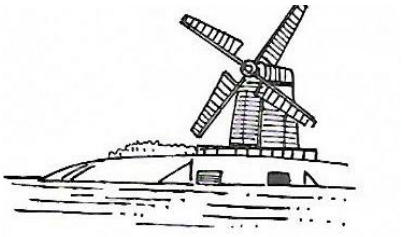
D 能可从一种形式转换至另一种形式或多种形式

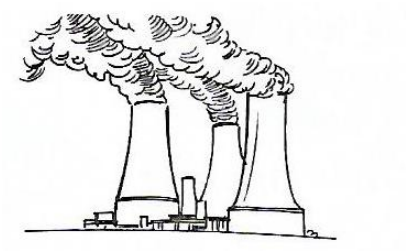
Energy can be transformed from one type to another or multiple types of energy

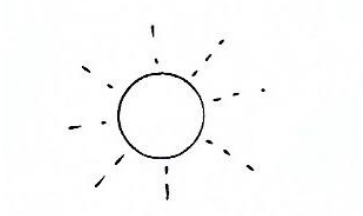
12. 哪项是不可更新的能源?

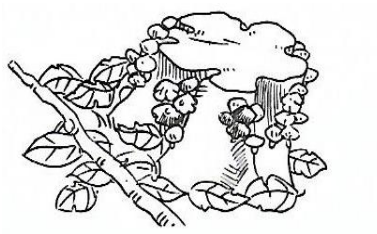
Which one is non-renewable energy?

7.2/LS7.2.1/PS2

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

7.1/LS7.1.4/PS5 (HOTs)

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

7.2/LS7.2.2/PS4

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

7.2/LS7.2.2/PS1

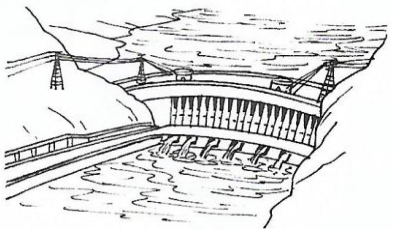


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

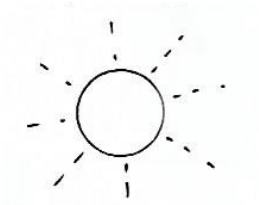


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

7.2/LS7.2.1/PS2

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

7.2/LS7.2.2/PS4

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

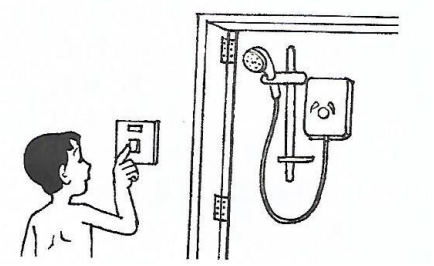


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

7.2/LS7.2.2/PS4

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。 *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

7.2/LS7.2.2/PS2

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

7.2/LS7.2.2/PS4

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

   Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

8.1/LS8.1.1/PS1

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

D 木材

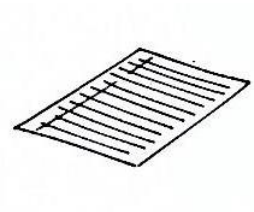
Wood

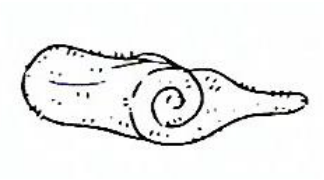
2. 哪种物品是用丝来制造?

Which item is made of silk?

8.1/LS8.1.1/PS1

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

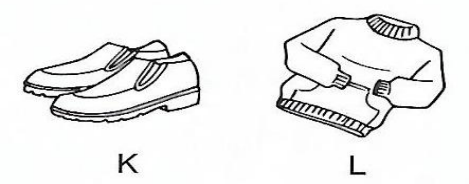


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

8.1/LS8.1.2/PS3

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

8.1/LS8.1.1/PS1

A P 和 Q

P and Q

B P 和 R

P and R

C Q 和 R

Q and R

D R 和 S

R and S

5. 图 3 显示一个分类图。

Figure 3 shows a classification diagram.

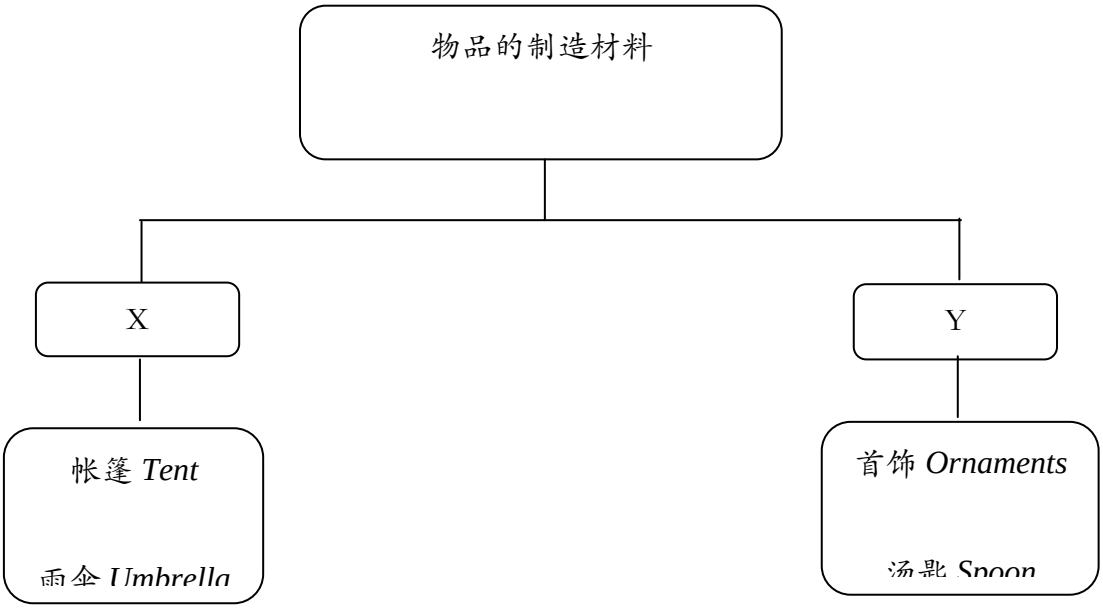


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

8.1/LS8.1.2/PS3

	X	Y
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革 *Leather*	塑料 *Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

8.1/LS8.1.1/PS1

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

8.1/LS8.1.1/PS2

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

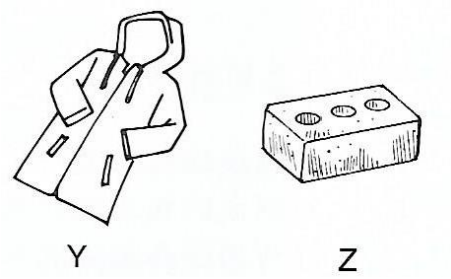


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

8.1/LS8.1.2/PS3

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

8.2/LS8.2.2/PS2

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

8.2/LS8.2.3/PS5 (HOTs)

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

8.2/LS8.2.3/PS4

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

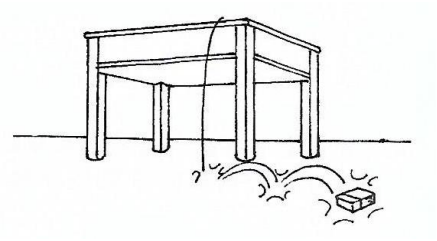


图 7

Diagram 7

8.2/LS8.2.4/PS5 (HOTs)

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮檫电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

8.2/LS8.2.1/PS5 (HOTs)

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会发亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

8.2/LS8.2.3/PS5 (HOTs)

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片 *Blade*	回形针 *Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

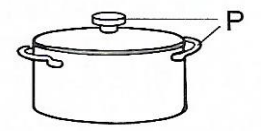


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

8.2/LS8.2.2/PS5 (HOTs)

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

8.2/LS8.2.3/PS5 (HOTs)

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

8.2/LS8.2.3/PS5 (HOTs)

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

8.2/LS8.2.3/PS5 (HOTs)

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

8.2/LS8.2.4/PS5 (HOTs)

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.



图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

8.2/LS8.2.3/PS5 (HOTs)

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

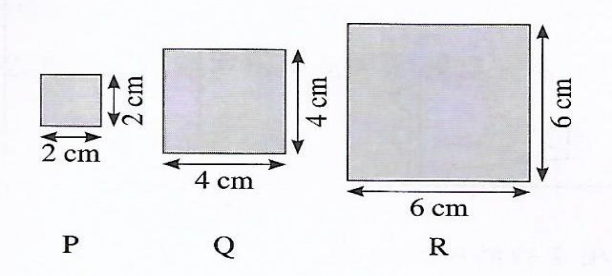


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

5.1/LS5.1.4/PS4

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

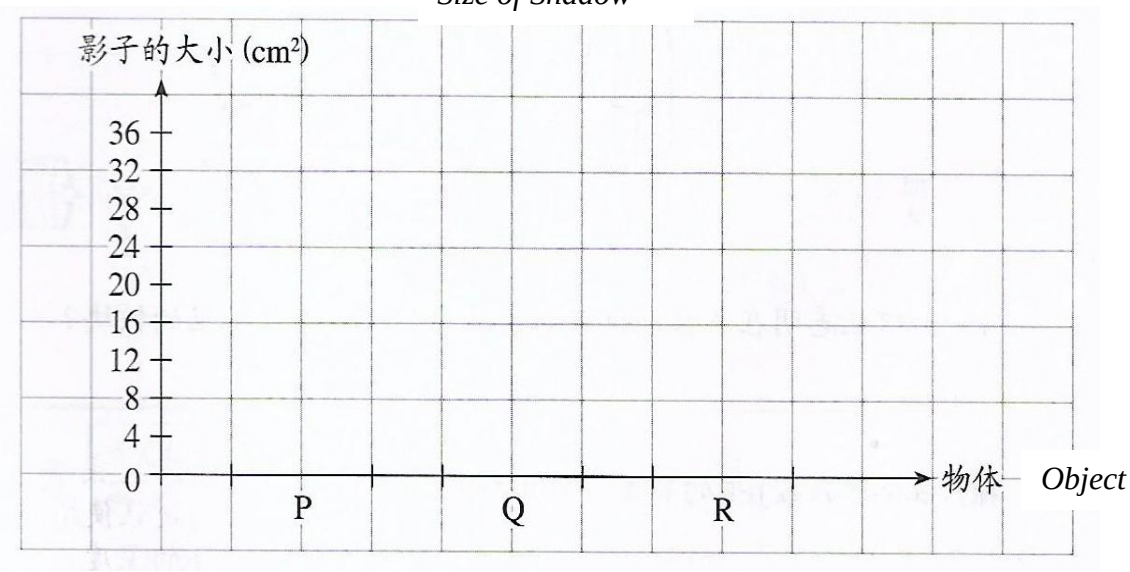
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。 *Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.*

5.1/LS5.1.3/PS5 (HOTs)

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

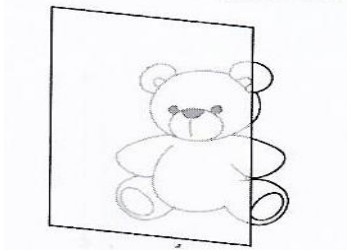
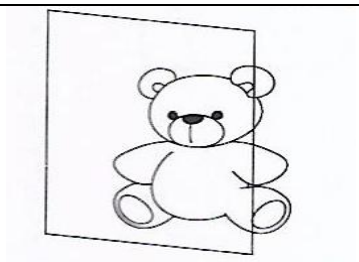
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

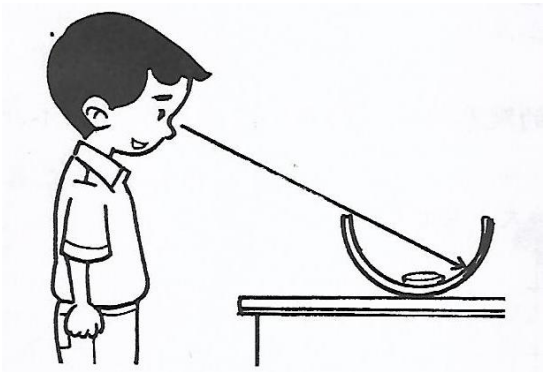


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

5.1/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

5.3/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

5.3/LS5.3.1/PS4

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

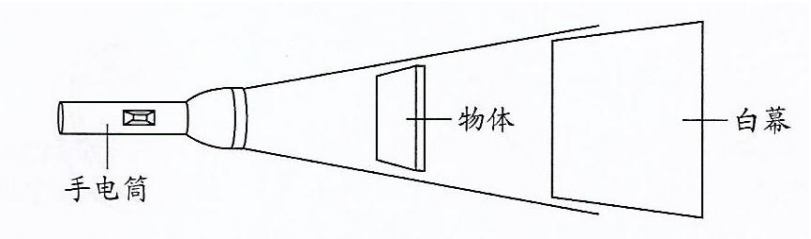


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

5.1/LS5.1.3/PS4

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

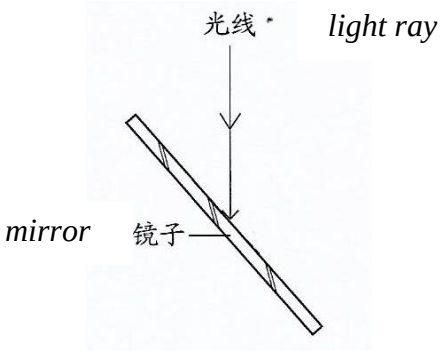


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

5.2/LS5.2.3/PS2

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

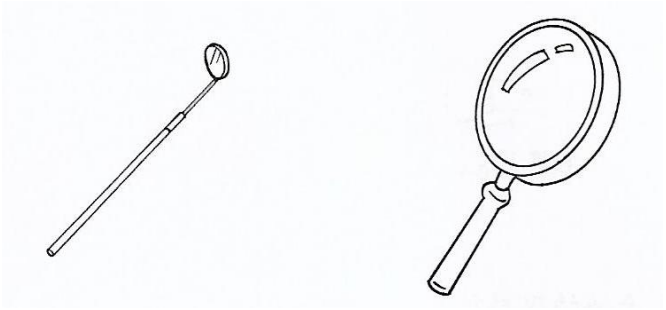


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

5.2/LS5.2.2/PS3

i. 口腔镜：_____

Dental mirror: _____

5.3/LS5.3.2/PS3

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

5.2/LS5.2.2/PS6 (HOTs)

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

5.3/LS5.3.2/PS6 (HOTs)

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

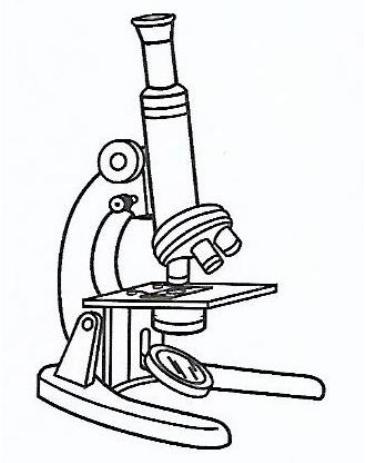


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

5.3/LS532.2/PS6 (HOTs)

【2分】

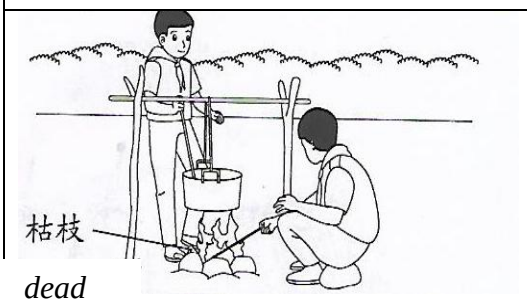
[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

S 组 *Team S*	T 组 *Team T*
	

dead

natural

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

7.1/LS7.1.2/PS1

i. S 组：_____

Team S: _____

ii. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

7.1/LS7.1.4/PS3

【
2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

7.2/LS7.2.1/PS2

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源?

Which energy source would you encourage them to use?

7.2/LS7.2.1/PS2

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

7.2/LS7.2.1/PS2

_____

【1分】

[1 mark]

2.

a) 什么是能?

What is energy?

7.1/LS7.1.1/PS1

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

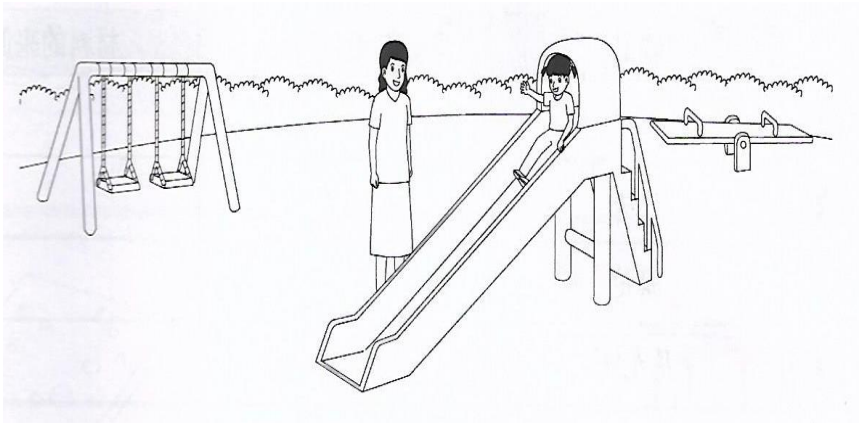


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能?

What kind of energy does my sister have on the slide?

7.1/LS7.1.3/PS1

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

7.1/LS7.1.4/PS3

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

7.1/LS7.1.4/PS3

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能 *Electrical energy* ⟶ *Light energy + Sound energy*

X电器是什么?

What is *appliance X*?

7.1/LS7.1.4/PS3

_____

【2分】
[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

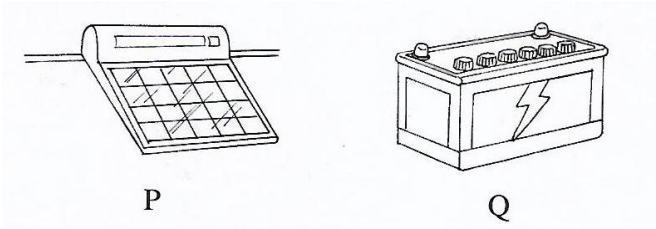


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

7.2/LS7.2.2/PS4

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

7.2/LS7.2.2/PS4

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

7.1/LS7.1.4/PS5 (HOTS)

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

7.1/LS7.1.2/PS2

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

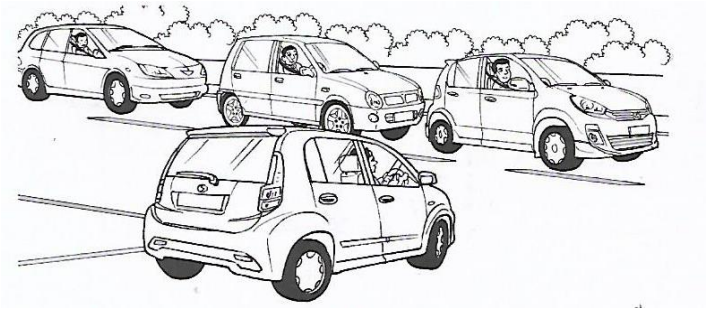


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

7.2/LS7.2.2/PS1

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

7.2/LS7.2.2/PS4)

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.

7.1/LS7.1.4/PS5 (HOTS)



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

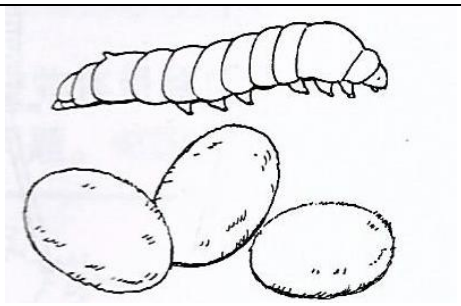
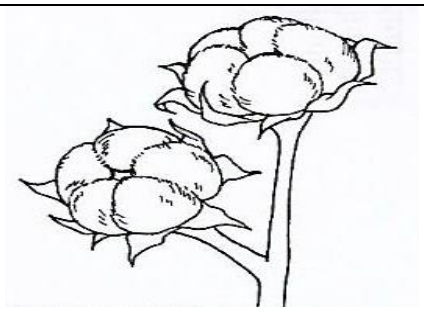
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

8.1/LS8.1.1/PS1

i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

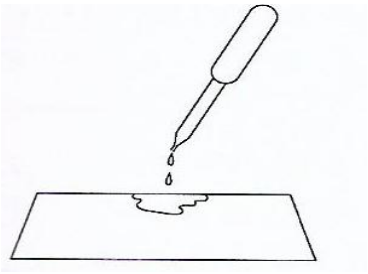
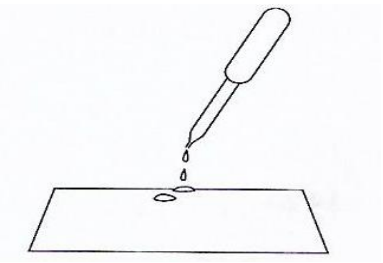
【2 分】

[2 marks]

b) 根据你在（a）项的答案，把水滴在P材料和Q材料上，它们的观察结果是怎样的？填写正确的答案。

Based on the energy formation, what kind of energy it is?

8.1/LS8.1.1/PS1

i)	ii)
	
_____ 材料 *Material* _____	_____ 材料 *Material* _____

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶？

Which material is suitable for dealing with overturned milk on the table?

8.2/LS8.2.1/PS5 (HOTs)

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

8.2/LS8.2.1/PS5 (HOTs)

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

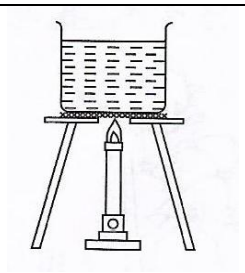
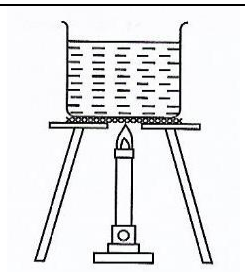
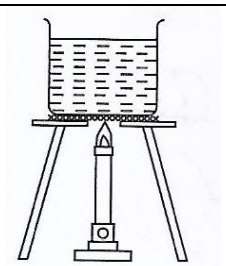
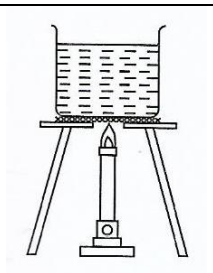
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

8.2/LS8.2.4/PS4

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

8.2/LS8.2.1/PS4

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

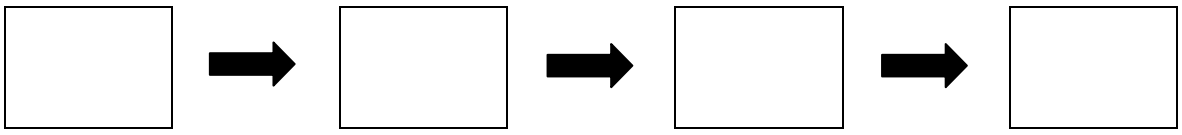
【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).

8.2/LS8.2.1/PS4



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

8.2/LS8.2.4/PS5 (HOTs)

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

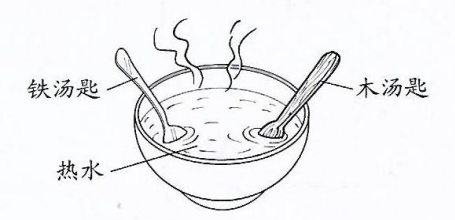


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

8.2/LS8.2.4/PS4

_____

【2 分】

[2 marks]

ii. 五分钟后，用手轻轻触摸铁汤匙和木汤匙。

After 5 minutes, lightly touch the iron spoon and wooden spoon with hands.

哪项观察是正确的？画 (/)。

Which observation is correct? Pick (/).

8.2/LS8.2.4/PS2

	铁汤匙比木汤匙热 *Iron spoon is hotter than wooden spoon.*
	木汤匙比铁汤匙热 *Wooden spoon is hotter than iron spoon.*
	铁汤匙是热的，木汤匙不热 *Iron spoon is hot, wooden spoon is not.*

【1 分】

[1 mark]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

8.2/LS8.2.4/PS5 (HOTs)

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

8.2/LS8.2.4/PS3

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

8.1/LS8.1.2/PS1

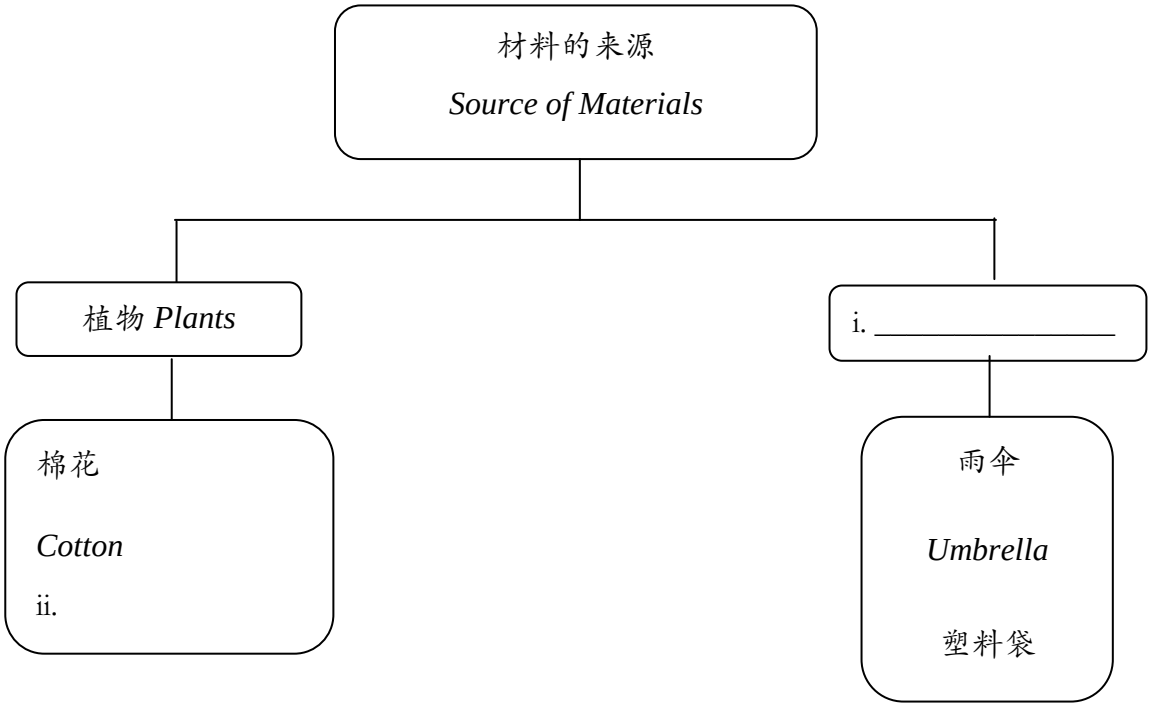


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

5. 能看到宠物在屋子里的情况。

   Can see the pet in the house.

6. 宠物在屋子里不会日晒雨淋。

   The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

8.2/LS8.2.2/PS5 (HOTs)

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

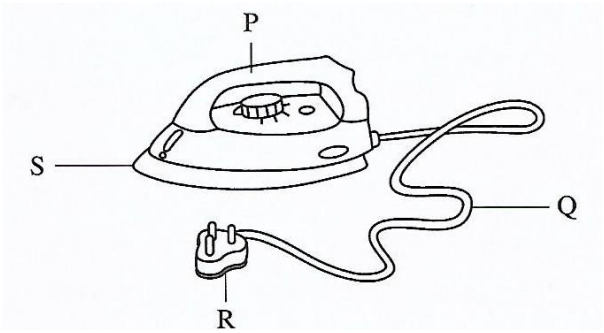


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

8.2/LS8.2.1/PS4

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

8.2/LS8.2.2/PS5 (HOTs)

_____

【1 分】

[2 marks]

APPENDIX L: Second Draft of Post-Test

四年级科学

Year 4 Science

前测

Post-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

甲组

Section A

（60%）

<u>指示 Instruction:</u>

- 本文包含 60 个多项选择题。

  This paper contains 60 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

   Diagram 1 shows a car driving at night.

5.1/LS5.1.1/PS4

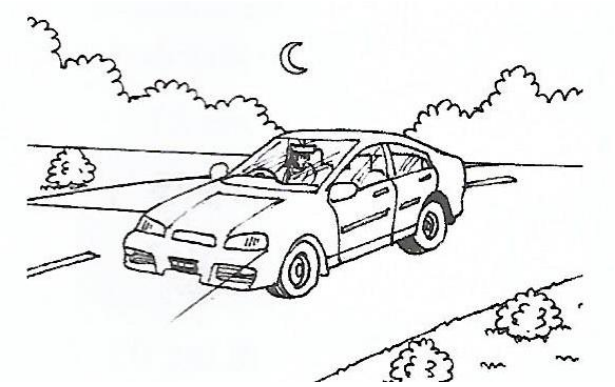


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么?

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

5.1/LS5.1.1/PS4

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

5.1/LS5.1.2/PS5 (HOTs)

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么？

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

5.1/LS5.1.3/PS5 (HOTs)

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体?

Which item is opaque?

5.1/LS5.1.2/PS1

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D 抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

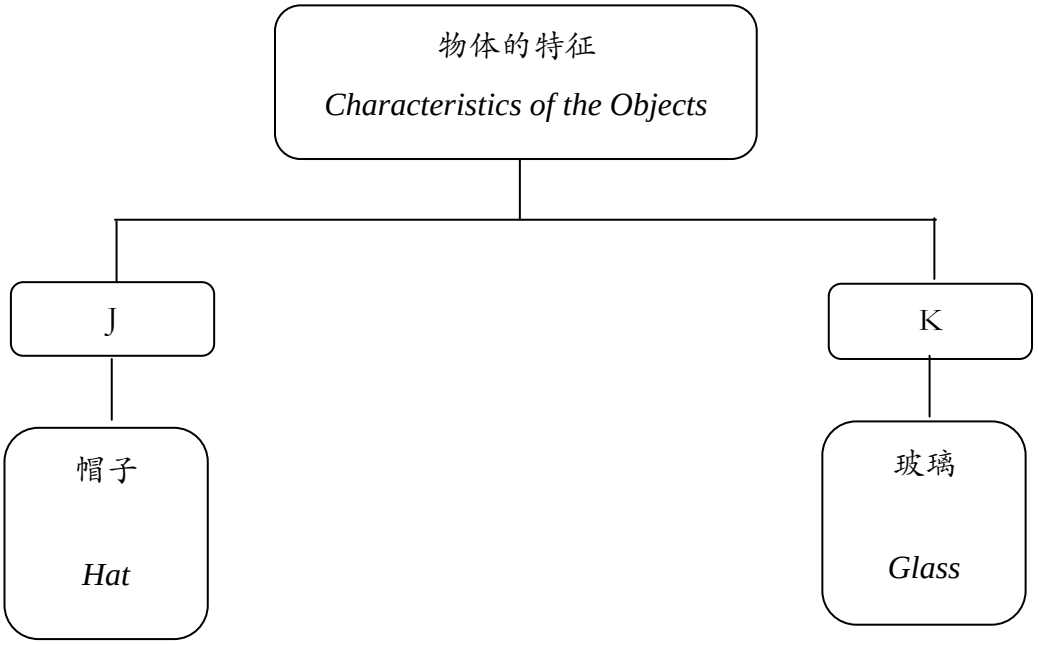


图 2

Diagram 2

5.1/LS5.1.2/PS3

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*

C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

5.1/LS5.1.4/PS5 (HOTs)

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

5.1/LS5.1.3/PS5 (HOTs)

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

5.1/LS5.1.3/PS5 (HOTs)

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

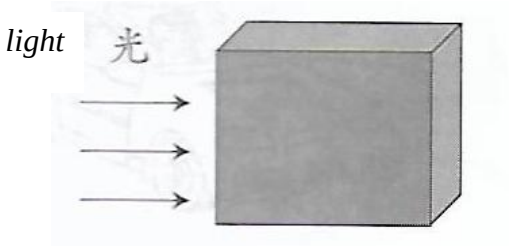


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

5.1/LS5.1.3/PS5 (HOTs)

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

5.1/LS5.1.4/PS5 (HOTs)

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 图 4 显示一个自然现象。

Diagram 4 shows a natural phenomenon.

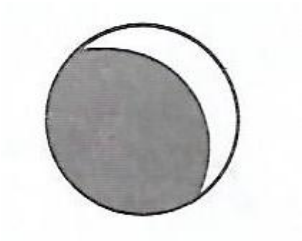


图 4

Diagram 4

哪项与图 4 的自然现象所显示的原理相同?

Which is the same principle as shown by the natural phenomenon in Diagram 4?

5.1/LS5.2.2/PS3

A 彩风用眼睛看报纸

Cai Feng reads the newspaper with her eyes

B 炫铃看着镜子来化妆

Hyun Jung looks in the mirror to put on a make-up

C 文邵看到汤匙在水中折断的现象

Wen Shao noticed the phenomenon of the spoon breaking in the water

D 善华从水面上看到鱼的位置和实际上鱼的位置不一样

The position of the fish that Shanhua sees from the water is different from the actual position of the fish

15. 下面是有关三个物体的影子的说明。

Below is an illustration of the shadows of three objects.

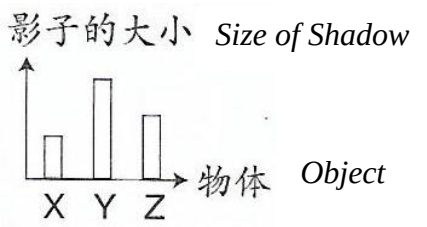
- 物体 X 的影子比物体 Z 的影子小。
  The shadow of object X is smaller than object Z.
- 物体 Y 的影子比物体 Z 的影子大。
  The shadow of object Y is larger than object Z.

哪个条形统计图正确地显示三个影子的长度?

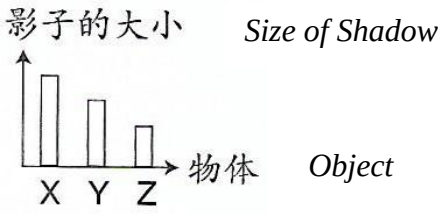
Which bar chart shows the length of the three shadows correctly?

5.1/LS5.1.3/PS5 (HOTs)

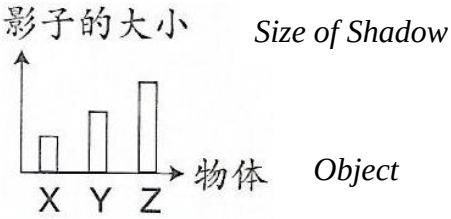
A



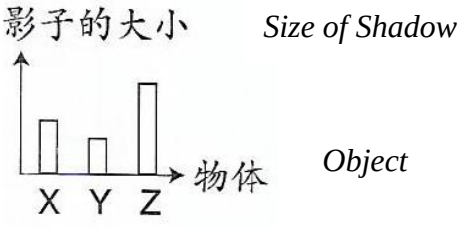
B



C



D



16. 什么是光的折射?

What is refraction of light?

5.3/LS5.3.1/PS1

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

17. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

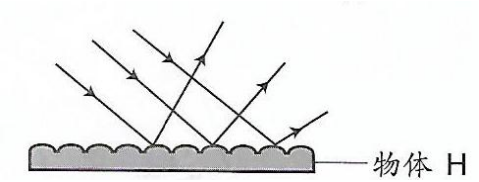


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

5.2/LS5.2.2/PS3

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

18. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

5.3/LS5.3.2/PS4

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

19. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

5.2/LS5.3.2/PS4

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

20. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

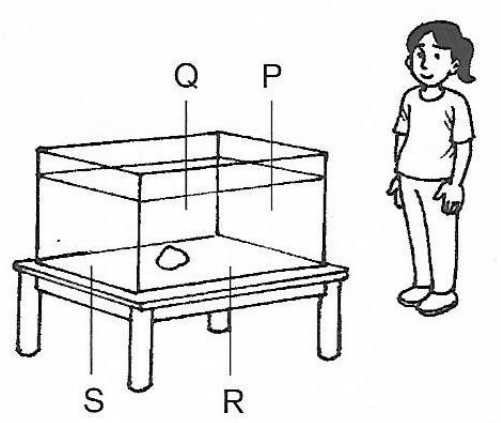


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置?

Which is the position of the stone observed by Shi Qi from the water?

5.3/LS5.3.2/PS4

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

   Diagram 1 shows a source of energy.

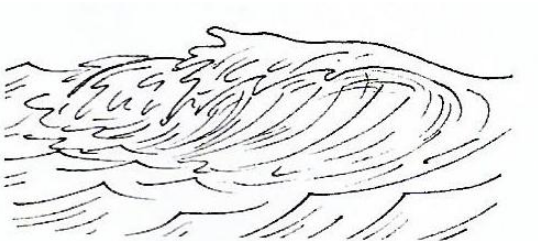


图 1

Diagram 1

哪项是图 1 的能的来源?

Which one is the source of the energy in Diagram 1?

7.1/LS7.1.2/PS1

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

7.1/LS7.1.2/PS2

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

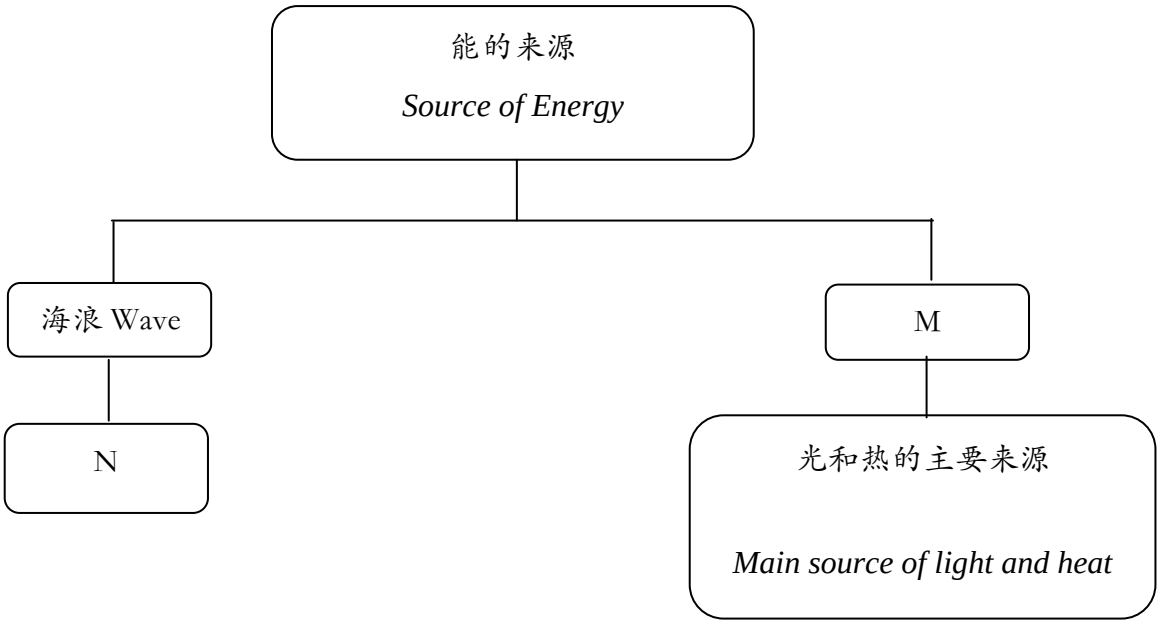


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

7.1/LS7.1.2/PS4

	M	N
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

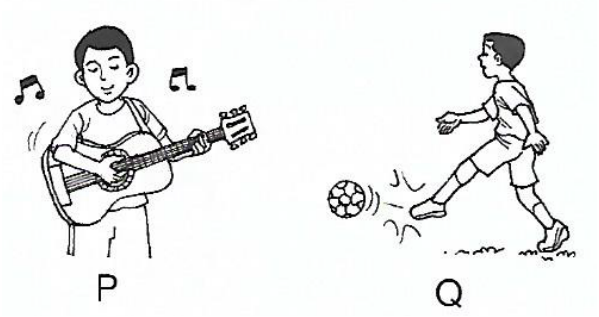


图 3

Diagram 3

活动 P 和活动 Q 具备什么能？

What kind of energy Activity P and Activity Q have?

7.1/LS7.1.4/PS1

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

7.1/LS7.1.3/PS1

A 热能

Heat energy

B 声能

Sound energy

C 动能

Kinetic energy

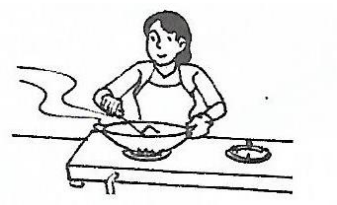
D 势能

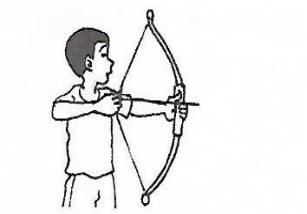
Potential energy

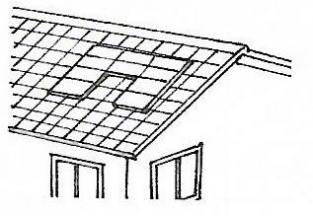
6. 哪个活动具备势能？

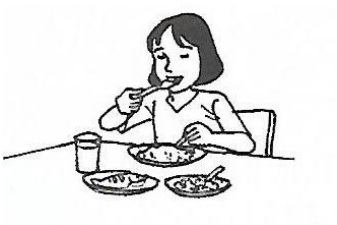
Which activity possess potential energy?

7.1/LS7.1.3/PS1

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

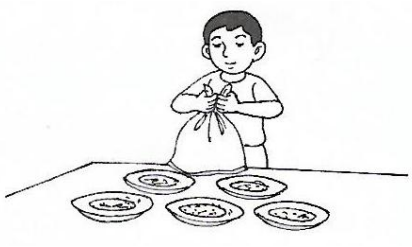


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

7.1/LS7.1.2/PS2

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

7.1/LS7.1.4/PS3

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

7.1/LS7.1.4/PS5 (HOTs)

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

7.1/LS7.1.4/PS5 (HOTs)

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

7.1/LS7.1.5/PS5 (HOTs)

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

There is only one type of energy

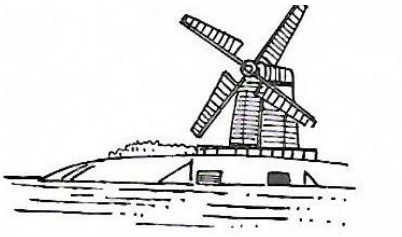
D 能可从一种形式转换至另一种形式或多种形式

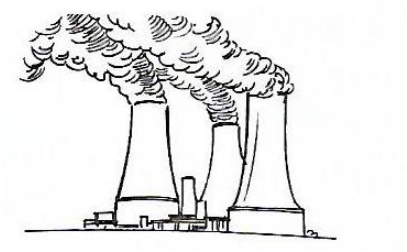
Energy can be transformed from one type to another or multiple types of energy

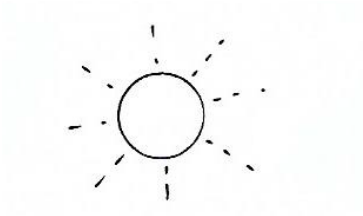
12. 哪项是不可更新的能源?

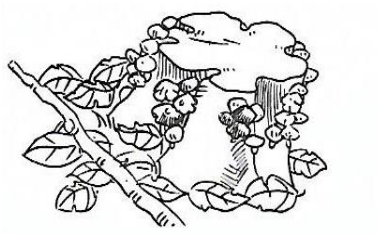
Which one is non-renewable energy?

7.2/LS7.2.1/PS2

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

7.1/LS7.1.4/PS5 (HOTs)

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

7.2/LS7.2.2/PS4

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

7.2/LS7.2.2/PS1

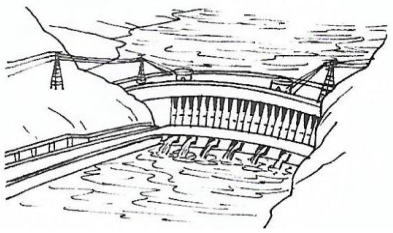


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

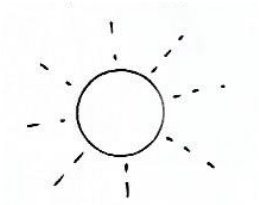


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

7.2/LS7.2.1/PS2

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

7.2/LS7.2.2/PS4

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

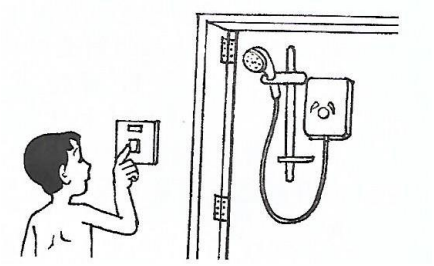


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

7.2/LS7.2.2/PS4

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。 *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

7.2/LS7.2.2/PS2

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

7.2/LS7.2.2/PS4

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

   Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

8.1/LS8.1.1/PS1

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

D 木材

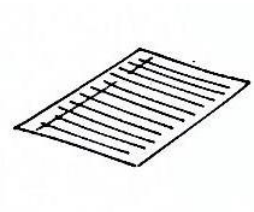
Wood

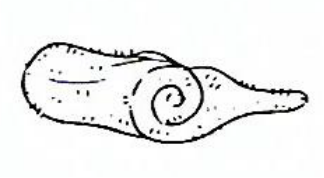
2. 哪种物品是用丝来制造?

Which item is made of silk?

8.1/LS8.1.1/PS1

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

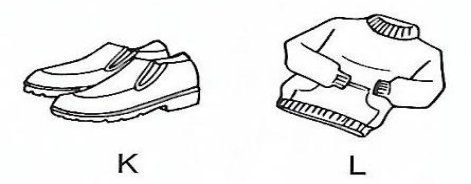


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

8.1/LS8.1.2/PS3

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

8.1/LS8.1.1/PS1

A P 和 Q

P and Q

B P 和 R

P and R

C Q 和 R

Q and R

D R 和 S

R and S

5. 图 3 显示一个分类图。

Figure 3 shows a classification diagram.

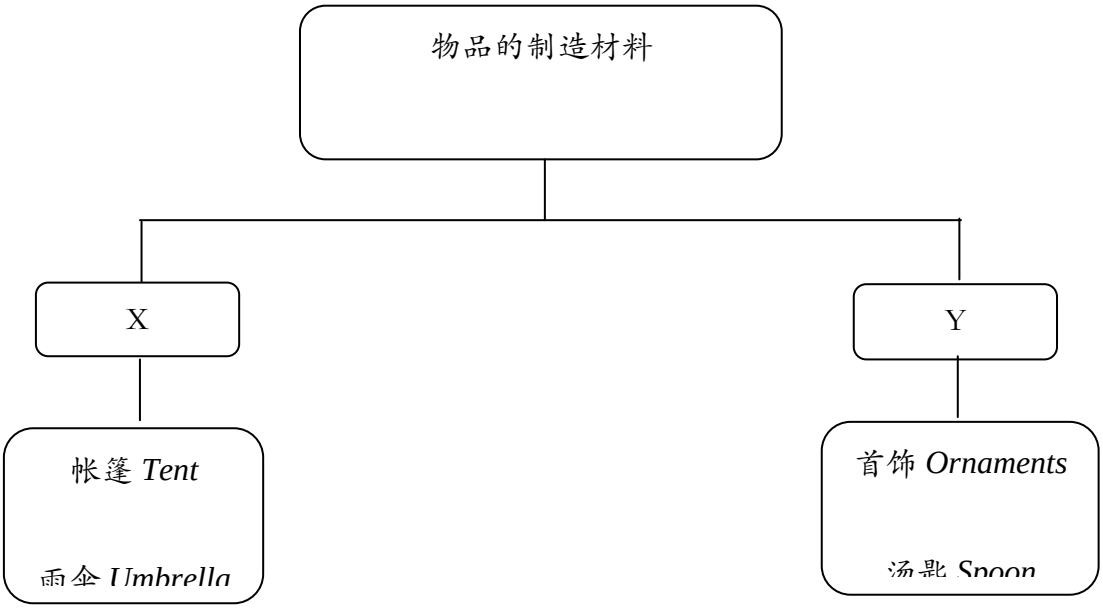


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

8.1/LS8.1.2/PS3

	X	Y
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革 *Leather*	塑料 *Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

8.1/LS8.1.1/PS1

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

8.1/LS8.1.1/PS2

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

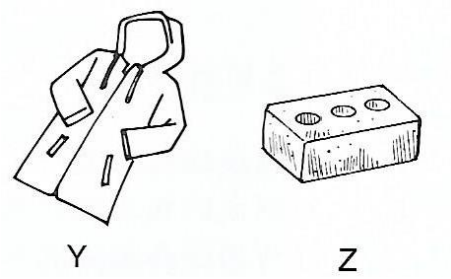


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

8.1/LS8.1.2/PS3

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

8.2/LS8.2.2/PS2

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

8.2/LS8.2.3/PS5 (HOTs)

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

8.2/LS8.2.3/PS4

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

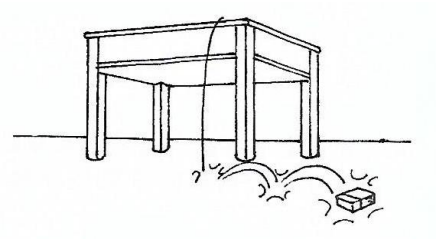


图 7

Diagram 7

8.2/LS8.2.4/PS5 (HOTs)

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮檫电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

8.2/LS8.2.1/PS5 (HOTs)

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会发亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

8.2/LS8.2.3/PS5 (HOTs)

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片 *Blade*	回形针 *Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

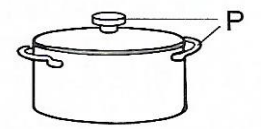


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

8.2/LS8.2.2/PS5 (HOTs)

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

8.2/LS8.2.3/PS5 (HOTs)

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

8.2/LS8.2.3/PS5 (HOTs)

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

8.2/LS8.2.3/PS5 (HOTs)

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

8.2/LS8.2.4/PS5 (HOTs)

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.



图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

8.2/LS8.2.3/PS5 (HOTs)

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

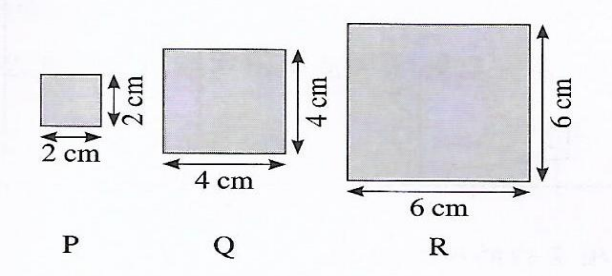


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

5.1/LS5.1.4/PS4

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

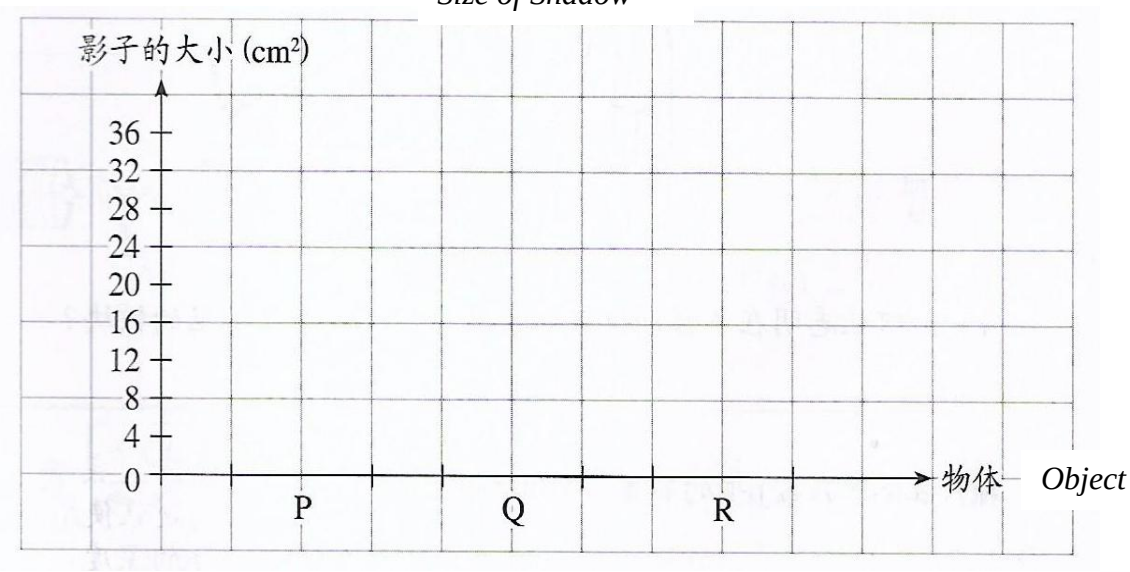
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。 *Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.*

5.1/LS5.1.3/PS5 (HOTs)

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

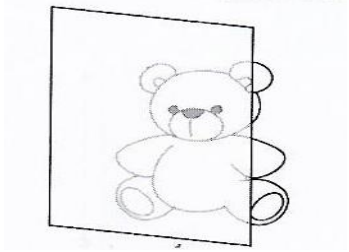
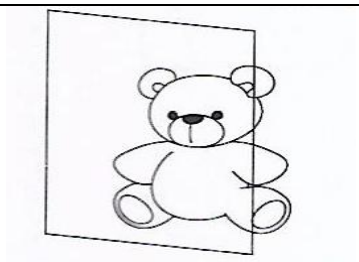
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

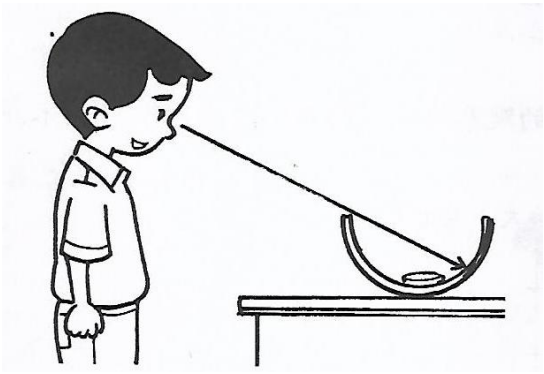


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

5.1/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

5.3/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

5.3/LS5.3.1/PS4

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

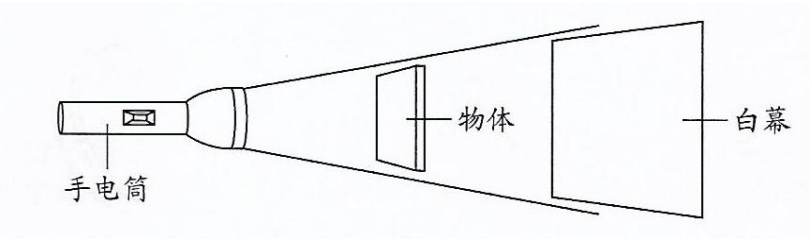


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

5.1/LS5.1.3/PS4

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

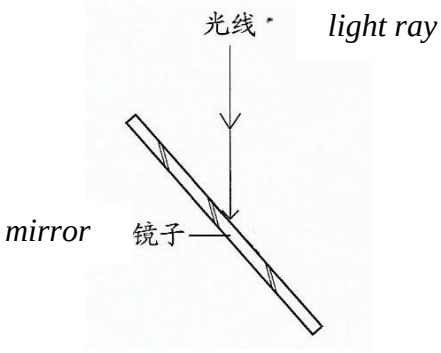


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

5.2/LS5.2.3/PS2

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

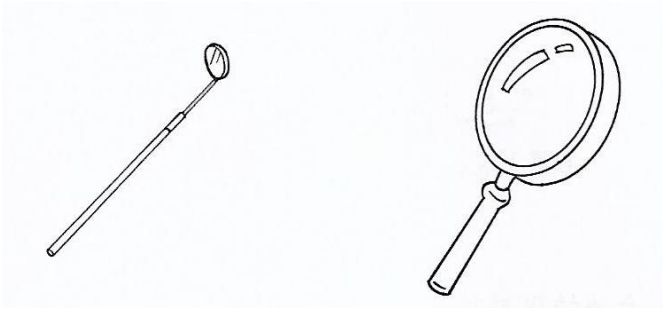


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

5.2/LS5.2.2/PS3

i. 口腔镜：_____

Dental mirror: _____

5.3/LS5.3.2/PS3

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

5.2/LS5.2.2/PS6 (HOTS)

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

5.3/LS5.3.2/PS6 (HOTs)

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

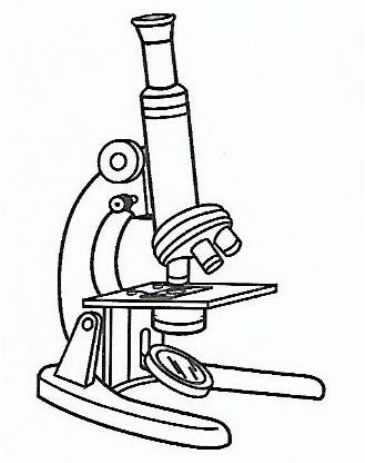


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

5.3/LS532.2/PS6 (HOTs)

【2分】

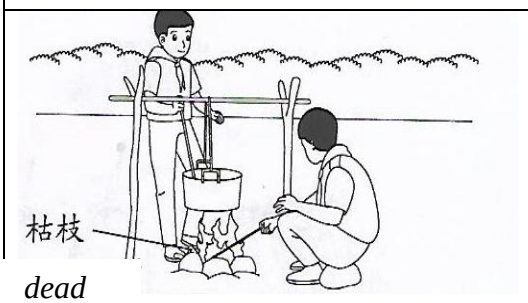
[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

S 组 *Team S*	T 组 *Team T*
	

dead

natural

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

7.1/LS7.1.2/PS1

iii. S 组：_____

Team S: _____

iv. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

7.1/LS7.1.4/PS3

【
2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

7.2/LS7.2.1/PS2

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源?

Which energy source would you encourage them to use?

7.2/LS7.2.1/PS2

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

7.2/LS7.2.1/PS2

_____

【1分】

[1 mark]

2.

a) 什么是能?

What is energy?

7.1/LS7.1.1/PS1

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

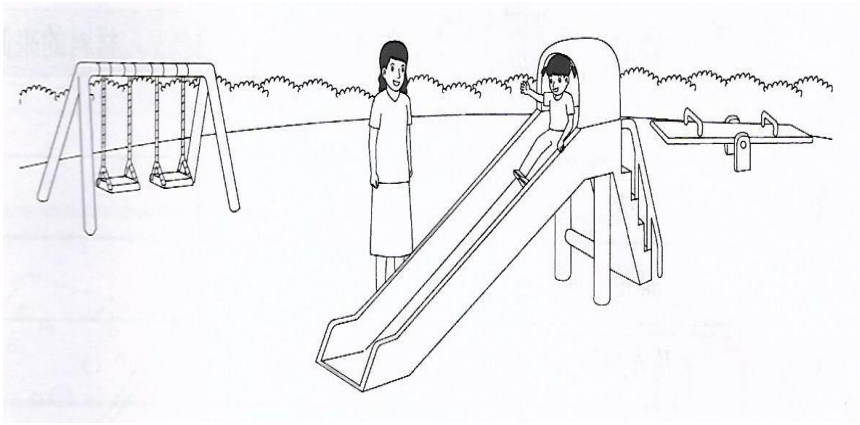


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能?

What kind of energy does my sister have on the slide?

7.1/LS7.1.3/PS1

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

7.1/LS7.1.4/PS3

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

7.1/LS7.1.4/PS3

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能
Electrical energy ⟶ *Light energy + Sound energy*

X电器是什么？

What is *appliance X*?

7.1/LS7.1.4/PS3

_____

【2分】
[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

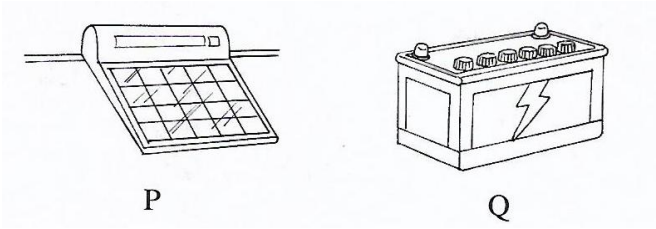


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

7.2/LS7.2.2/PS4

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

7.2/LS7.2.2/PS4

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

7.1/LS7.1.4/PS5 (HOTs)

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

7.1/LS7.1.2/PS2

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

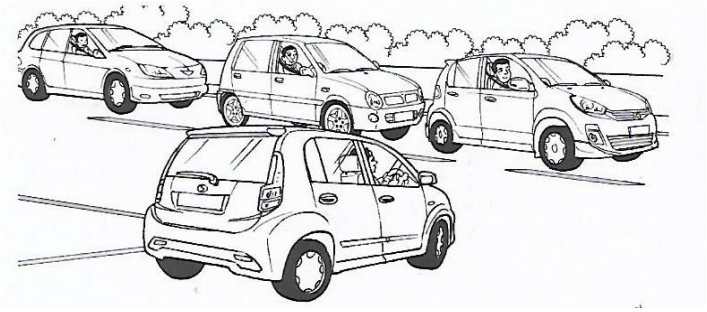


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

7.2/LS7.2.2/PS1

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

7.2/LS7.2.2/PS4)

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.

7.1/LS7.1.4/PS5 (HOTs)



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

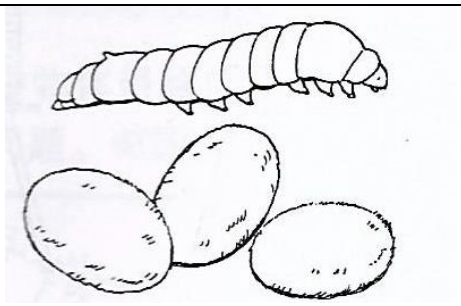
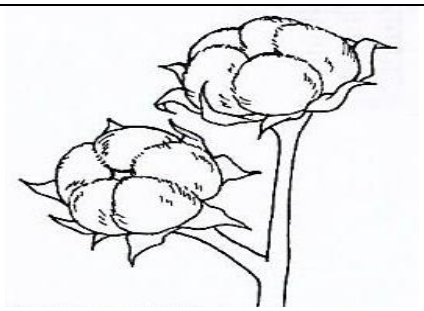
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

8.1/LS8.1.1/PS1

i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

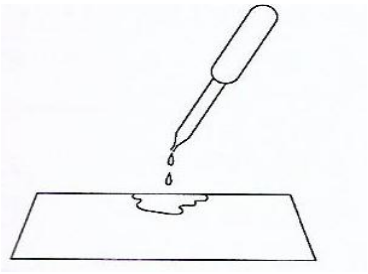
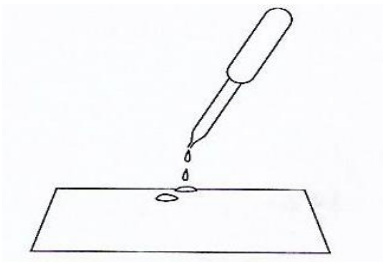
【2 分】

[2 marks]

b) 根据你在（a）项的答案，把水滴在P材料和Q材料上，它们的观察结果是怎样的？填写正确的答案。

Based on the energy formation, what kind of energy it is?

8.1/LS8.1.1/PS1

i)	ii)
	
_____ 材料 *Material* _____	_____ 材料 *Material* _____

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶？

Which material is suitable for dealing with overturned milk on the table?

8.2/LS8.2.1/PS5 (HOTs)

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

8.2/LS8.2.1/PS5 (HOTs)

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

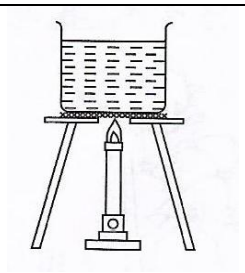
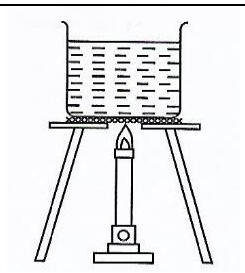
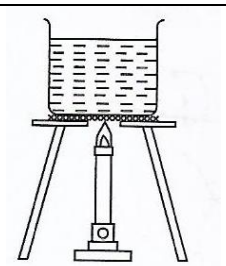
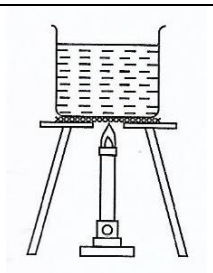
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

8.2/LS8.2.4/PS4

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

8.2/LS8.2.1/PS4

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

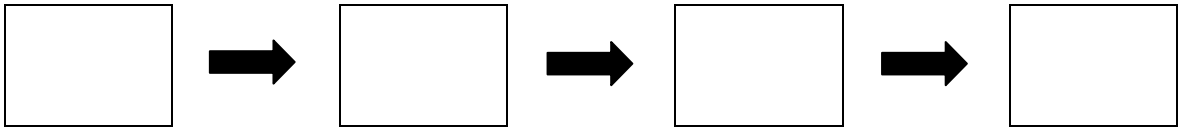
【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).

8.2/LS8.2.1/PS4



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

8.2/LS8.2.4/PS5 (HOTs)

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

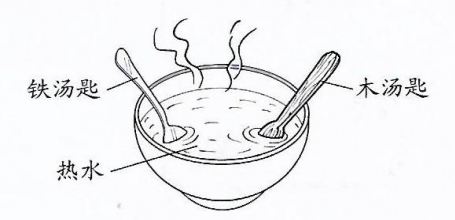


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

8.2/LS8.2.4/PS4

_____

【2 分】

[2 marks]

ii. 五分钟后，用手轻轻触摸铁汤匙和木汤匙。

After 5 minutes, lightly touch the iron spoon and wooden spoon with hands.

哪项观察是正确的？画 (/)。

Which observation is correct? Pick (/).

8.2/LS8.2.4/PS2

	铁汤匙比木汤匙热 *Iron spoon is hotter than wooden spoon.*
	木汤匙比铁汤匙热 *Wooden spoon is hotter than iron spoon.*
	铁汤匙是热的，木汤匙不热 *Iron spoon is hot, wooden spoon is not.*

【1 分】

[1 mark]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

8.2/LS8.2.4/PS5 (HOTs)

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

8.2/LS8.2.4/PS3

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

8.1/LS8.1.2/PS1

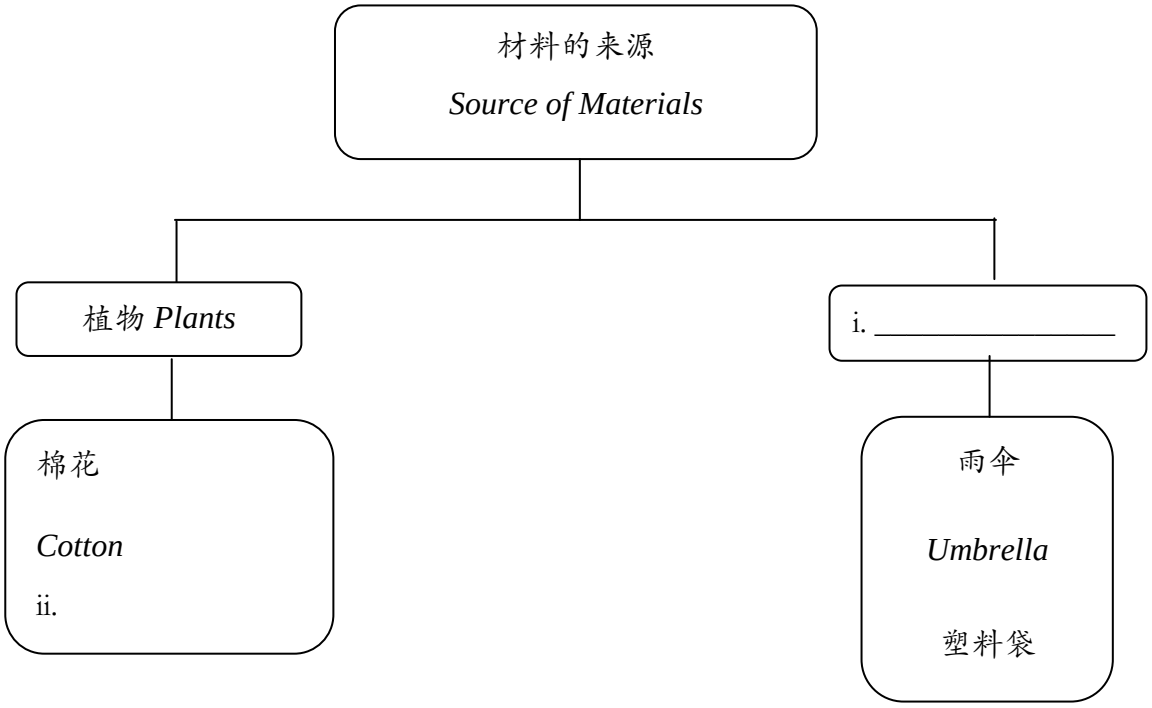


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

7. 能看到宠物在屋子里的情况。

   Can see the pet in the house.

8. 宠物在屋子里不会日晒雨淋。

   The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

8.2/LS8.2.2/PS5 (HOTs)

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

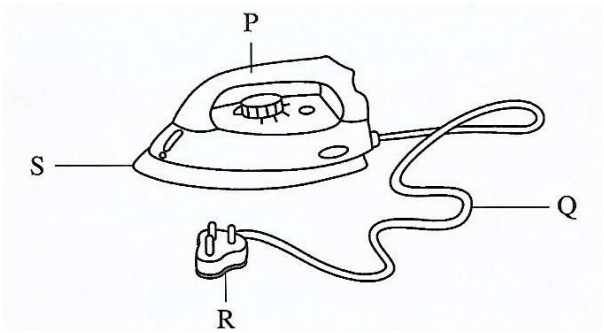


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

8.2/LS8.2.1/PS4

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

8.2/LS8.2.2/PS5 (HOTs)

_____

【1 分】

[2 marks]

APPENDIX M: Final Draft of Pre-Test

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

甲组

Section A

（58%）

<u>指示 Instruction:</u>

- 本文包含 58 个多项选择题。

  This paper contains 58 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

   Diagram 1 shows a car driving at night.

5.1/LS5.1.1/PS4

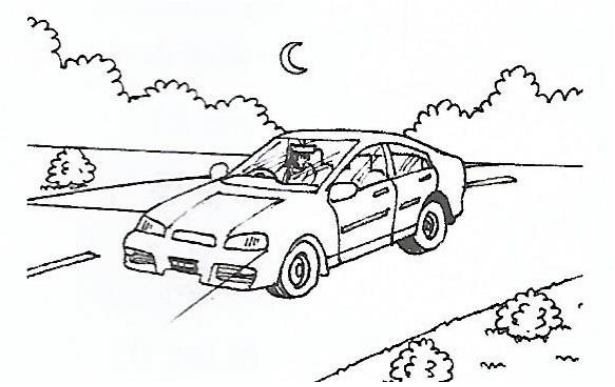


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么？

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

5.1/LS5.1.1/PS4

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

5.1/LS5.1.2/PS5 (HOTs)

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

5.1/LS5.1.4/PS5 (HOTS)

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么？

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

5.1/LS5.1.3/PS5 (HOTs)

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体?

Which item is opaque?

5.1/LS5.1.2/PS1

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D 抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

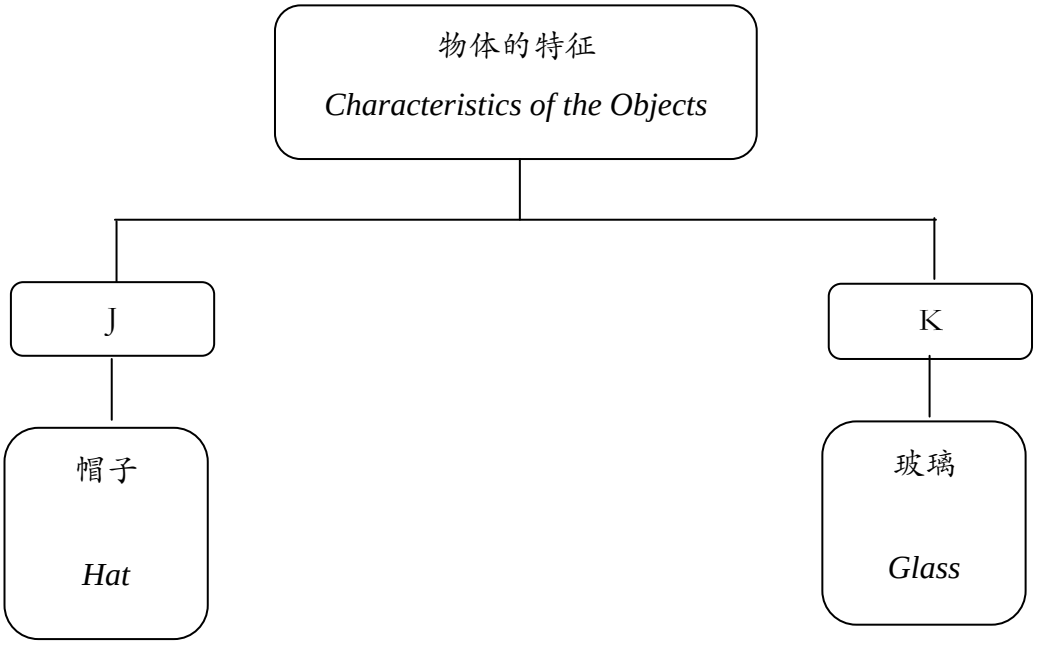


图 2

Diagram 2

5.1/LS5.1.2/PS3

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*

C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

5.1/LS5.1.4/PS5 (HOTs)

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

5.1/LS5.1.3/PS5 (HOTs)

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

5.1/LS5.1.3/PS5 (HOTs)

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

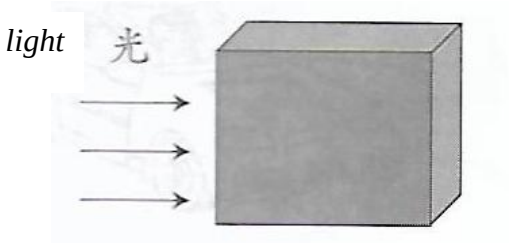


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

5.1/LS5.1.3/PS5 (HOTs)

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

5.1/LS5.1.4/PS5 (HOTs)

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 什么是光的折射?

What is refraction of light?

5.3/LS5.3.1/PS1

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

15. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

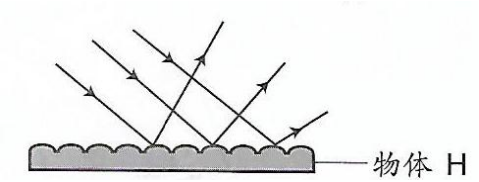


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

5.2/LS5.2.2/PS3

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

16. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

5.3/LS5.3.2/PS4

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

17. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

5.2/LS5.3.2/PS4

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

18. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

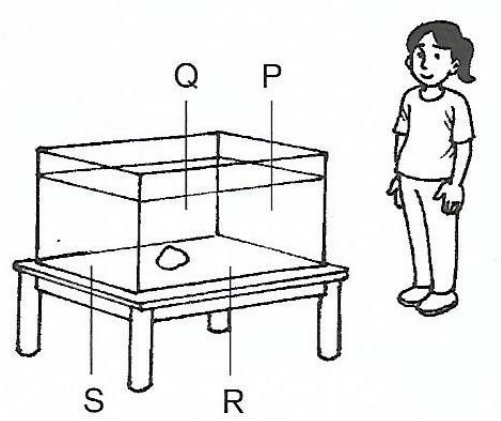


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置?

Which is the position of the stone observed by Shi Qi from the water?

5.3/LS5.3.2/PS4

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

   Diagram 1 shows a source of energy.

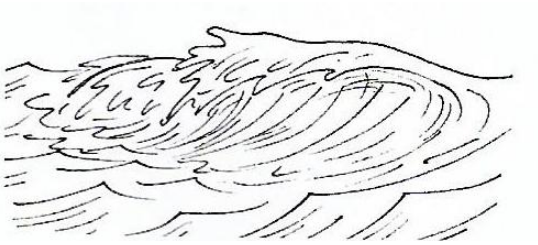


图 1

Diagram 1

哪项是图 1 的能的来源?

Which one is the source of the energy in Diagram 1?

7.1/LS7.1.2/PS1

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

7.1/LS7.1.2/PS2

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

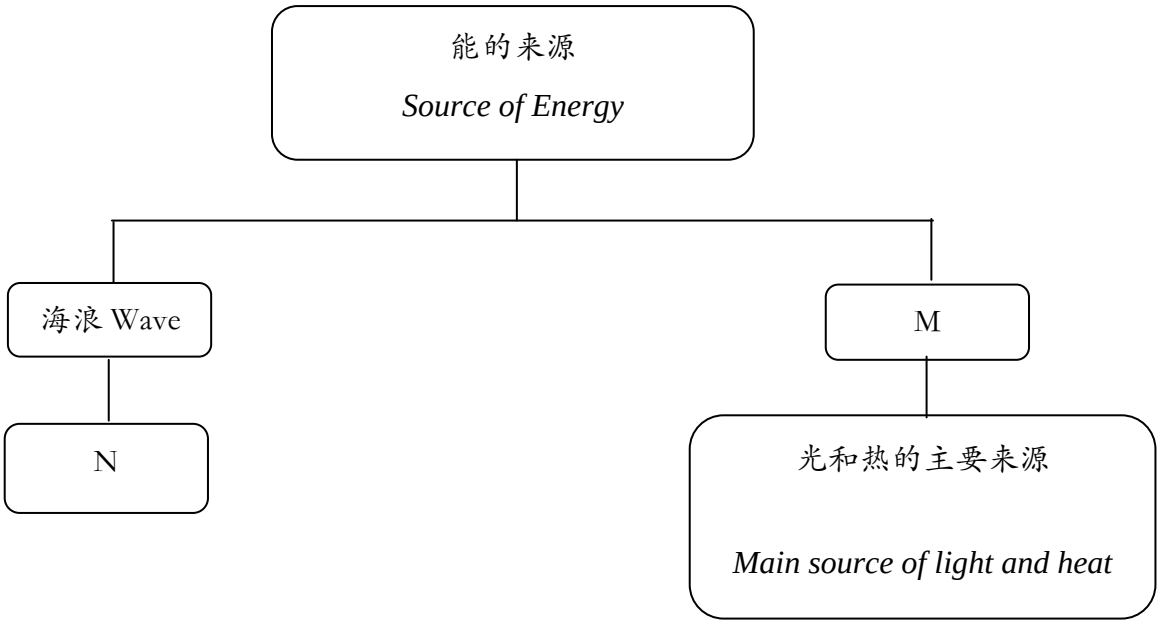


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

7.1/LS7.1.2/PS4

	M	N
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

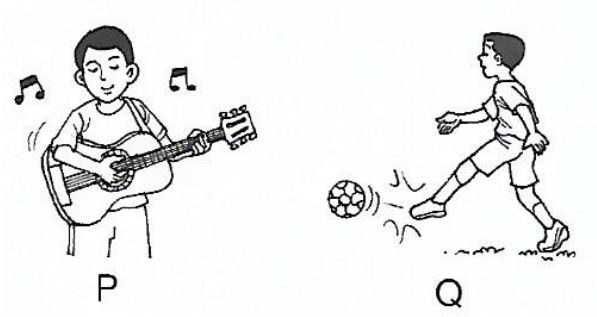


图 3

Diagram 3

活动 P 和活动 Q 具备什么能?

What kind of energy Activity P and Activity Q have?

7.1/LS7.1.4/PS1

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

7.1/LS7.1.3/PS1

A 热能

Heat energy

B 声能

Sound energy

C 动能

Kinetic energy

D 势能

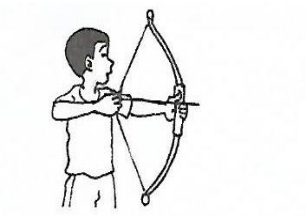
Potential energy

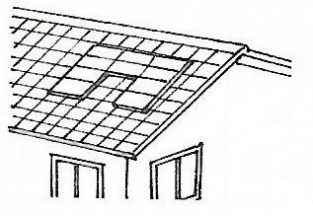
6. 哪个活动具备势能？

Which activity possess potential energy?

7.1/LS7.1.3/PS1

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

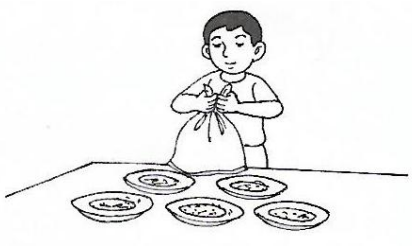


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

7.1/LS7.1.2/PS2

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

7.1/LS7.1.4/PS3

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

7.1/LS7.1.4/PS5 (HOTs)

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

7.1/LS7.1.4/PS5 (HOTs)

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

7.1/LS7.1.5/PS5 (HOTs)

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

There is only one type of energy

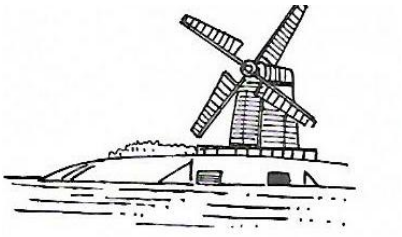
D 能可从一种形式转换至另一种形式或多种形式

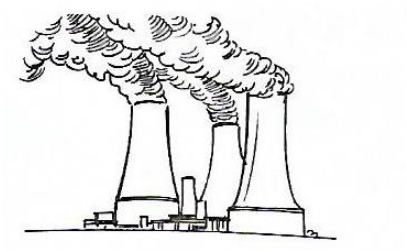
Energy can be transformed from one type to another or multiple types of energy

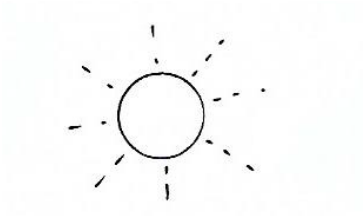
12. 哪项是不可更新的能源?

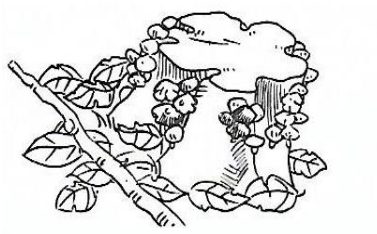
Which one is non-renewable energy?

7.2/LS7.2.1/PS2

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

7.1/LS7.1.4/PS5 (HOTs)

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

7.2/LS7.2.2/PS4

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

7.2/LS7.2.2/PS1

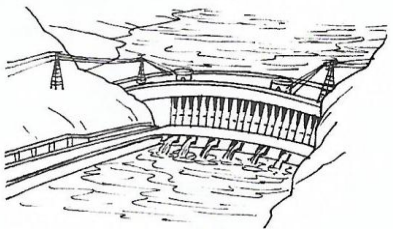


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

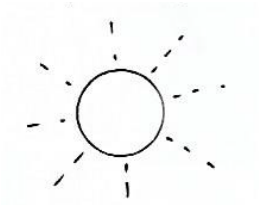


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

7.2/LS7.2.1/PS2

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

7.2/LS7.2.2/PS4

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

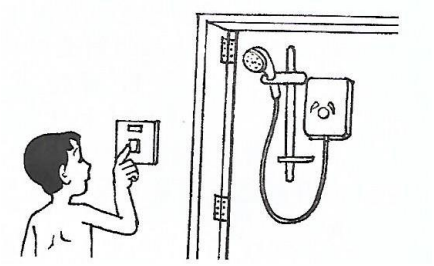


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

7.2/LS7.2.2/PS4

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。 *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

7.2/LS7.2.2/PS2

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

7.2/LS7.2.2/PS4

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

   Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

8.1/LS8.1.1/PS1

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

D 木材

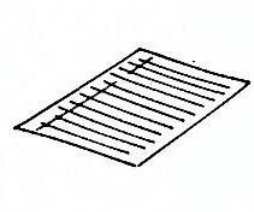
Wood

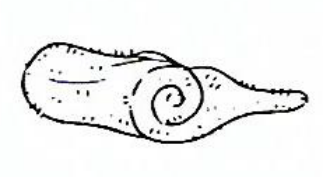
2. 哪种物品是用丝来制造?

Which item is made of silk?

8.1/LS8.1.1/PS1

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

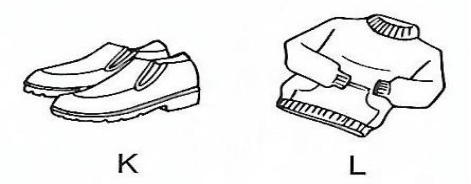


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

8.1/LS8.1.2/PS3

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

8.1/LS8.1.1/PS1

A P 和 Q

P and Q

B P 和 R

P and R

C Q 和 R

Q and R

D R 和 S

R and S

5. 图 3 显示一个分类图。

Figure 3 shows a classification diagram.

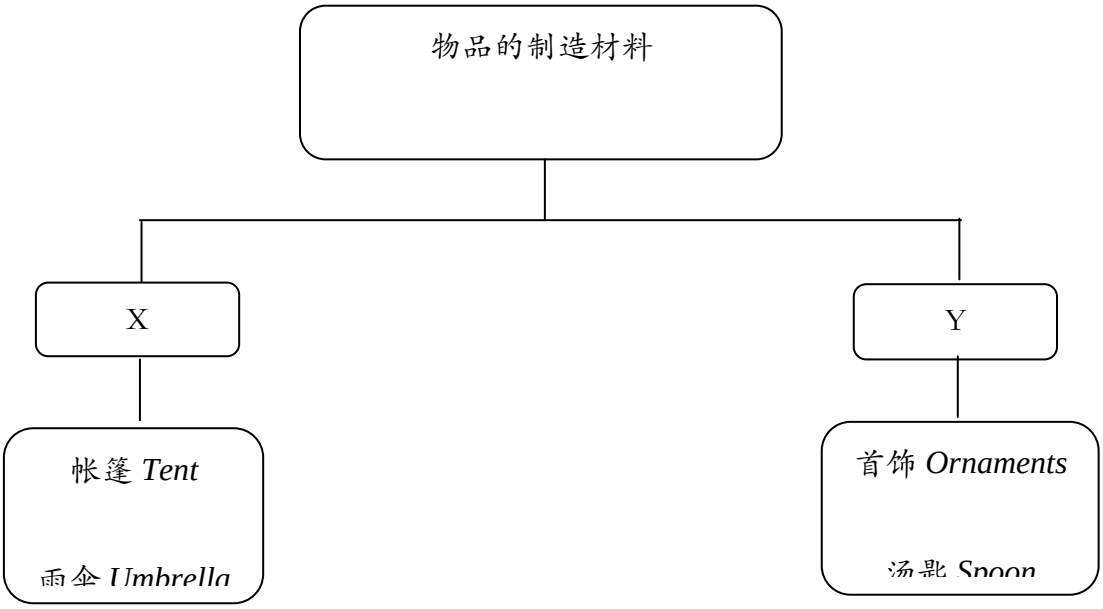


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

8.1/LS8.1.2/PS3

	X	Y
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革 *Leather*	塑料 *Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

8.1/LS8.1.1/PS1

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

8.1/LS8.1.1/PS2

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

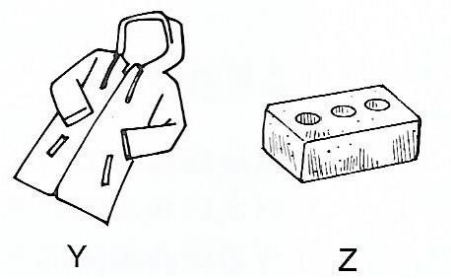


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

8.1/LS8.1.2/PS3

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

8.2/LS8.2.2/PS2

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

8.2/LS8.2.3/PS5 (HOTs)

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

8.2/LS8.2.3/PS4

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

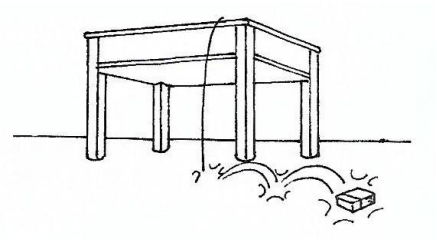


图 7

Diagram 7

8.2/LS8.2.4/PS5 (HOTs)

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮檫电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

8.2/LS8.2.1/PS5 (HOTs)

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会发亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

8.2/LS8.2.3/PS5 (HOTs)

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片 *Blade*	回形针 *Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

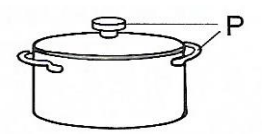


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

8.2/LS8.2.2/PS5 (HOTs)

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

8.2/LS8.2.3/PS5 (HOTs)

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

8.2/LS8.2.3/PS5 (HOTs)

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

8.2/LS8.2.3/PS5 (HOTs)

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

8.2/LS8.2.4/PS5 (HOTs)

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.



图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

8.2/LS8.2.3/PS5 (HOTs)

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

前测

Pre-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

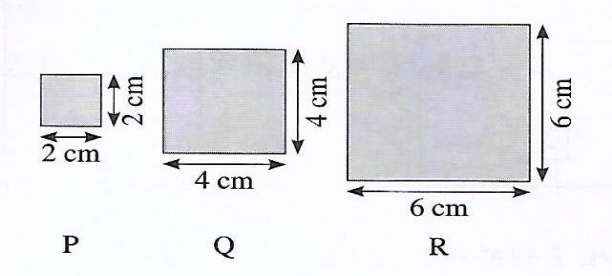


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

5.1/LS5.1.4/PS4

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

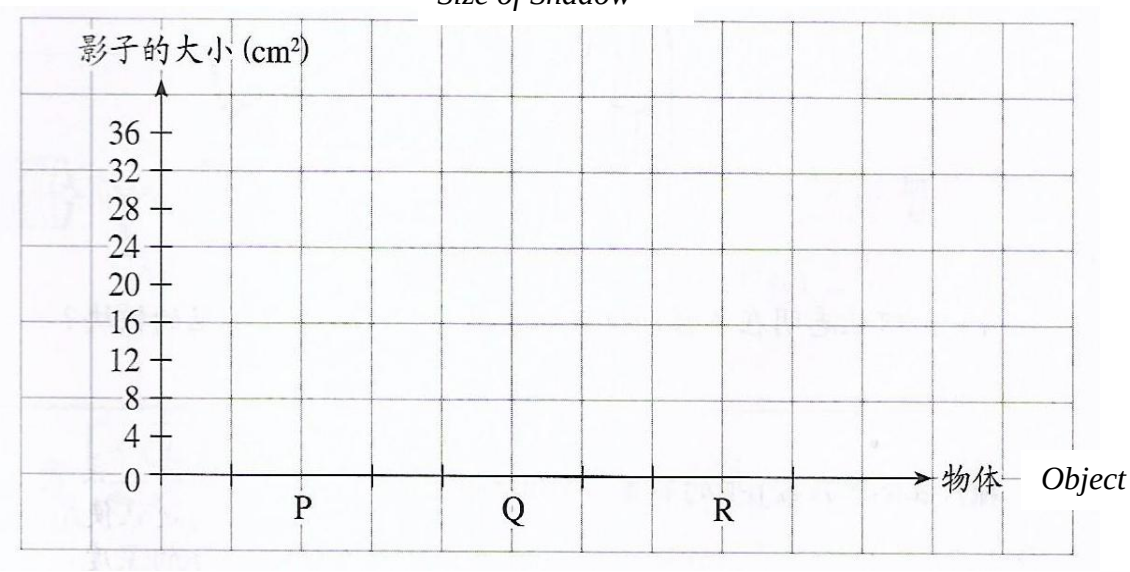
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。 *Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.*

5.1/LS5.1.3/PS5 (HOTs)

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

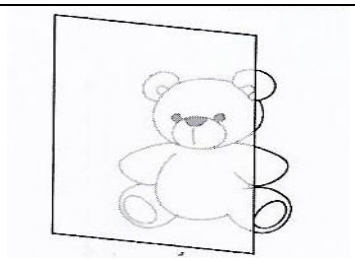
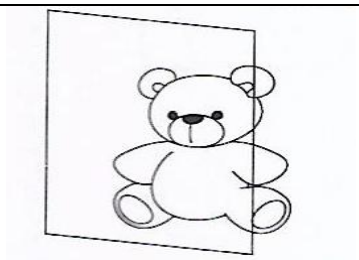
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

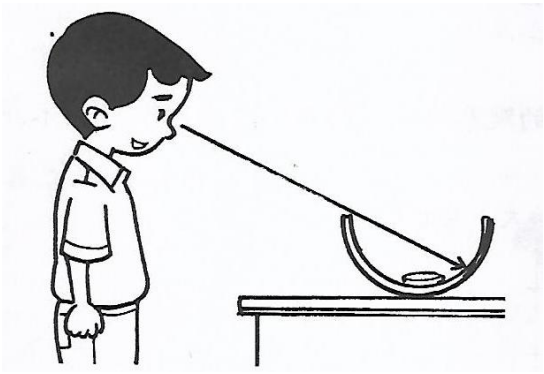


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

5.1/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

5.3/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

5.3/LS5.3.1/PS4

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

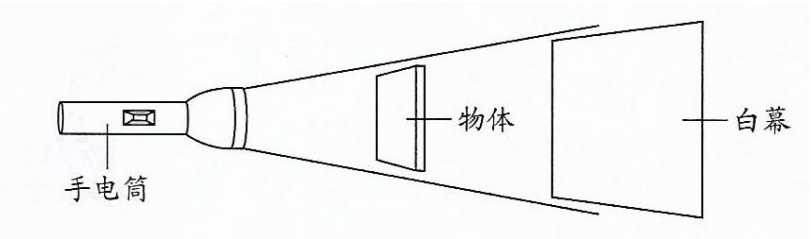


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

5.1/LS5.1.3/PS4

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

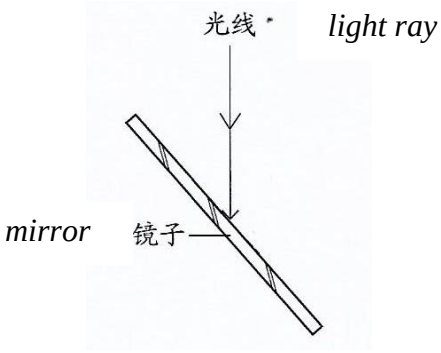


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

5.2/LS5.2.3/PS2

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

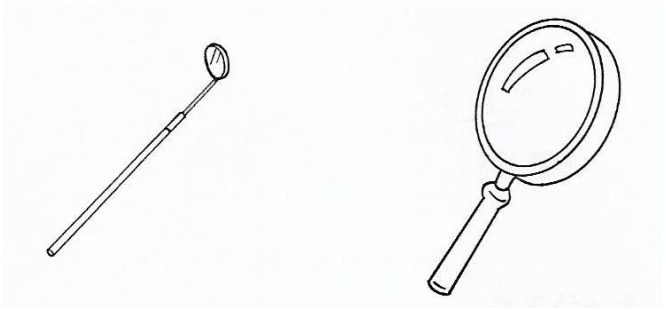


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

5.2/LS5.2.2/PS3

i. 口腔镜：_____

Dental mirror: _____

5.3/LS5.3.2/PS3

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

5.2/LS5.2.2/PS6 (HOTs)

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

5.3/LS5.3.2/PS6 (HOTs)

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

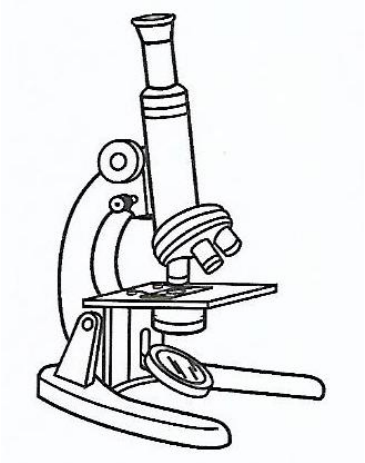


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

5.3/LS532.2/PS6 (HOTs)

【2分】

[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

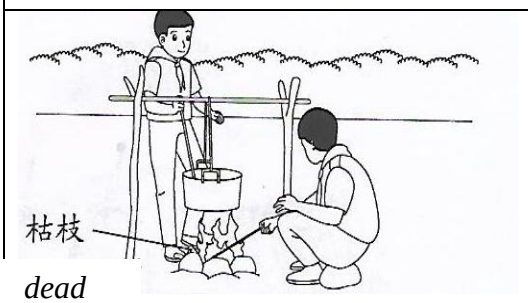
S 组 *Team S*	T 组 *Team T*
	
dead branches	*natural*

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

7.1/LS7.1.2/PS1

i. S 组：_____

Team S: _____

ii. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

7.1/LS7.1.4/PS3

【
2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

7.2/LS7.2.1/PS2

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源?

Which energy source would you encourage them to use?

7.2/LS7.2.1/PS2

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

7.2/LS7.2.1/PS2

_____

【1分】

[1 mark]

2.

a) 什么是能?

What is energy?

7.1/LS7.1.1/PS1

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

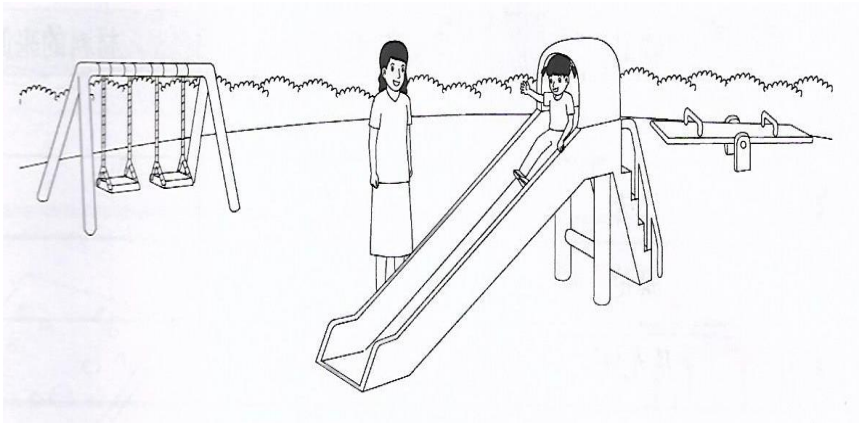


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能?

What kind of energy does my sister have on the slide?

7.1/LS7.1.3/PS1

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

7.1/LS7.1.4/PS3

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

7.1/LS7.1.4/PS3

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能 *Electrical energy* ⟶ *Light energy + Sound energy*

X电器是什么?

What is *appliance X*?

7.1/LS7.1.4/PS3

_____

【2分】
[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

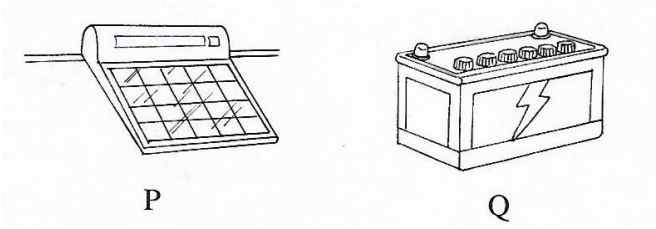


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

7.2/LS7.2.2/PS4

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

7.2/LS7.2.2/PS4

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

7.1/LS7.1.4/PS5 (HOTs)

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

7.1/LS7.1.2/PS2

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

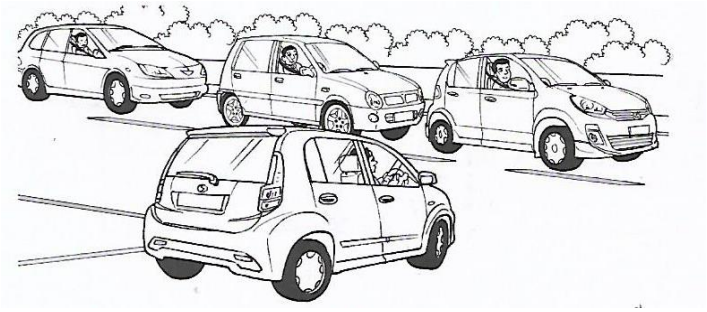


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

7.2/LS7.2.2/PS1

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

7.2/LS7.2.2/PS4)

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.

7.1/LS7.1.4/PS5 (HOTs)



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

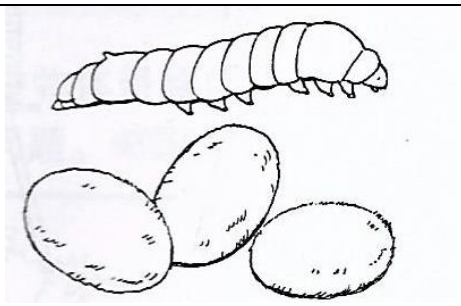
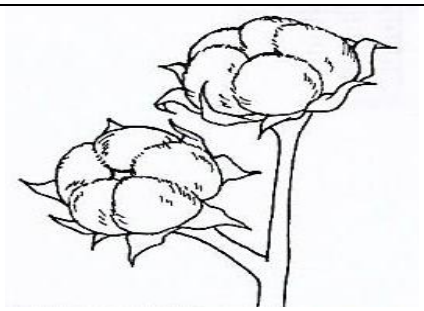
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

8.1/LS8.1.1/PS1

i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶?

Which material is suitable for dealing with overturned milk on the table?

8.2/LS8.2.1/PS5 (HOTs)

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

8.2/LS8.2.1/PS5 (HOTs)

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

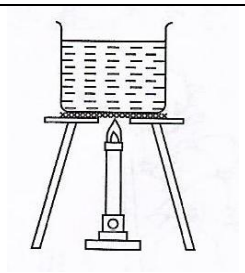
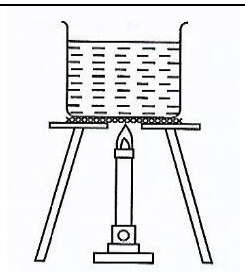
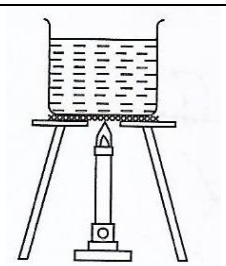
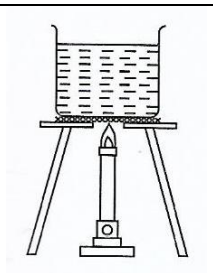
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

8.2/LS8.2.4/PS4

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

8.2/LS8.2.1/PS4

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

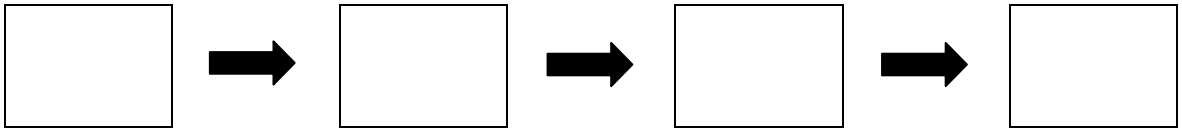
【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).

8.2/LS8.2.1/PS4



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

8.2/LS8.2.4/PS5 (HOTs)

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

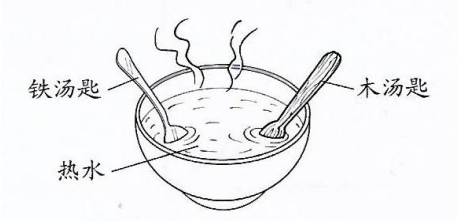


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

8.2/LS8.2.4/PS4

_____

【2 分】

[2 marks]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

8.2/LS8.2.4/PS5 (HOTs)

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

8.2/LS8.2.4/PS3

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

8.1/LS8.1.2/PS1

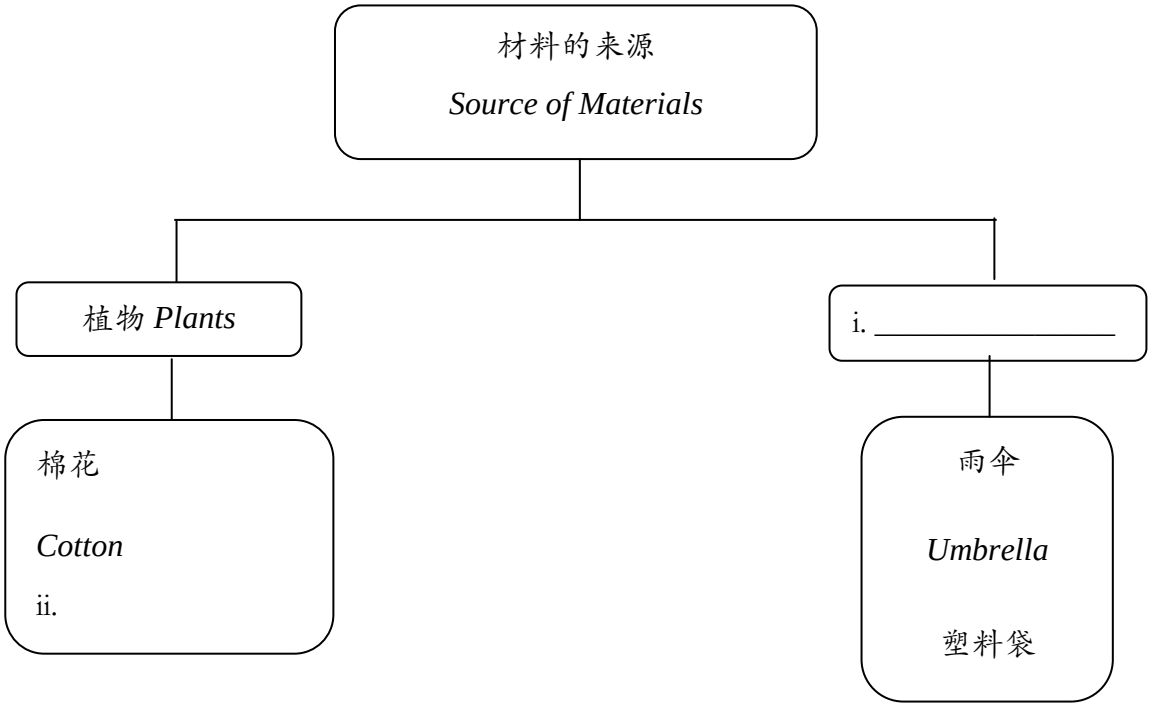


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

9. 能看到宠物在屋子里的情况。

   Can see the pet in the house.

10. 宠物在屋子里不会日晒雨淋。

    The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

8.2/LS8.2.2/PS5 (HOTs)

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

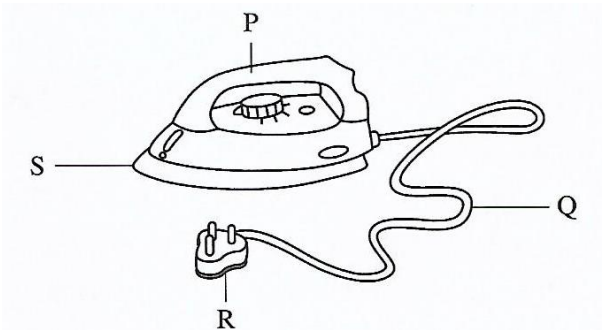


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

8.2/LS8.2.1/PS4

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

8.2/LS8.2.2/PS5 (HOTs)

_____

【1 分】

[2 marks]

APPENDIX N: Final Draft of Post-Test

四年级科学

Year 4 Science

后测

Post-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

甲组

Section A

（58%）

指示 Instruction:

- 本文包含 58 个多项选择题。

  This paper contains 58 multiple-choice questions.
- 你必须回答所有问题。

  You are required to answer all the questions.
- 每个问题有 4 个选项，分别是 A，B，C 和 D。你只需要圈出**一个**答案。

  *Each question has 4 options which are A, B, C and D. You are required to circle **one answer only**.*

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图 1 显示一辆汽车在夜晚行驶的情况。

   Diagram 1 shows a car driving at night.

5.1/LS5.1.1/PS4

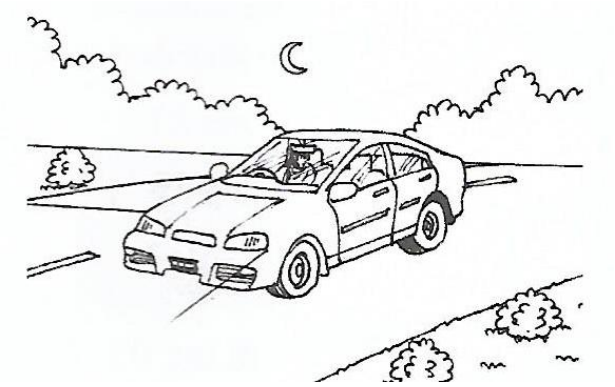


图 1

Diagram 1

哪项有关图 1 情况的说明是正确的?

Which statement about the situation in Diagram 1 is correct?

A 光会沿着直线传播

Light travels in straight lines

B 光会穿透任何物体

Light can penetrate any object.

C 光的传播没有距离限制

There is no distance limit for the propagation of light.

D 光的传播不会造成影子

Light travels without creating shadows

2. 宇杰在漆黑的房间打开手电筒，他无法照亮整个房间。为什么？

Yu Jie turned on the flashlight in the dark room, he couldn't illuminate the whole room. Why?

5.1/LS5.1.1/PS4

A 手电筒的光线不足

Insufficient light from the torchlight

B 手电筒的电量不足

The torchlight is low on power

C 手电筒的体积太小了

The torchlight is too small

D 手电筒的光线集中照射一个方向

The light of the torchlight is concentrated in one direction

3. 维康通过一张卡片的洞看到蜡烛的光。当他用一张纸摆放在卡片和蜡烛的中间，将会怎样?

Wei Kang saw the candle light through a hole in a card. What happens when he puts a piece of paper between the card and the candle?

5.1/LS5.1.2/PS5 (HOTs)

A 蜡烛的光会灭掉

The light of the candle will be put out

B 蜡烛的光被反射

The light of candle is reflected

C 维康看不到蜡烛的光

Wei Kang can't see the light of the candle

D 维康还能看到蜡烛的光

Wei Kang can still see the light of candle

4. 下面是有关李雯的实验的说明。

The following is the statement of Li Wen's experiment.

李雯用手电筒照射保鲜膜时，没有看到影子。 *When Li Wen irradiated the plastic wrap with a torchlight, she didn't see a shadow.*

哪项最适合解释实验结果的说明?

Which statement best explains the results of the experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 保鲜膜是透明体

Plastic wrap is transparent

B 保鲜膜是不透明体

Plastic wrap is opaque

C 保鲜膜是半透明体

Plastic wrap is translucent

D 保鲜膜本身没有影子

The plastic wrap itself has no shadow

5. 物品 J 被光线照射时，会形成一个模糊的影子。物品 J 最有可能是什么？

When Item J is hit by light, it will form a blurry shadow. What item J is most likely to be?

5.1/LS5.1.3/PS5 (HOTs)

A 钥匙

Key

B 玻璃

Glass

C 手帕

Handkerchief

D 抽图纸

Drawing paper

6. 哪个物品是不透明体？

Which item is opaque?

5.1/LS5.1.2/PS1

A 镜子

Mirror

B 卡片

Card

C 塑料袋

Plastic bag

D　抽图纸

Drawing paper

7. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

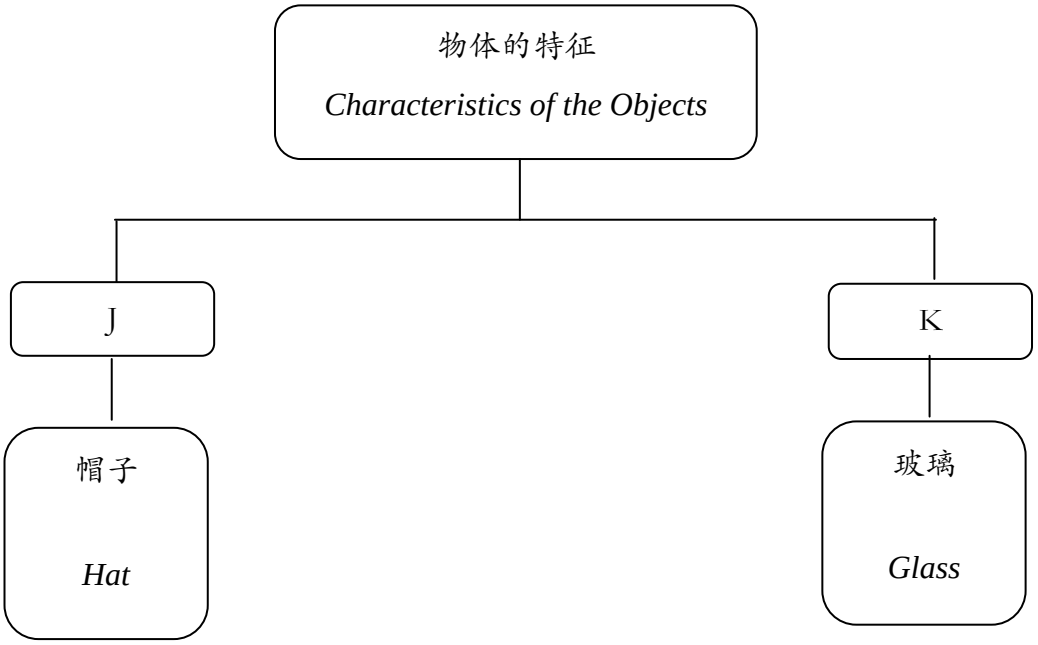


图 2

Diagram 2

5.1/LS5.1.2/PS3

哪项是 J 和 K?

Which are J and K?

	J	**K**
A	透明体 *Transparent*	半透明体 *Translucent*
B	不透明体 *Opaque*	透明体 *Transparent*

C	半透明体 *Translucent*	不透明体 *Opaque*
D	半透明体 *Translucent*	透明体 *Opaque*

8. 羽柔进行一项有关影子的实验。她用手电筒照射三种物品，并记录结果。表 1 显示实验结果。

Yu Rou conducts an experiment about shadows. She shines a torchlight on three objects and records the results. Table 1 shows the experimental results.

物品 ***Item***	**影子的清晰度** ***Sharpness of the Shadows***
P	没有影子 *No image*
Q	清晰的影子 *Clear image*
R	模糊的影子 *Blurred image*

表 1

Table 1

根据以上的实验，可作出什么结论?

What conclusions can be drawn from the above experiments?

5.1/LS5.1.4/PS5 (HOTs)

A 物品的透光能力会影响影子的清晰度

The light transmittance of an item affects the sharpness of shadows

B 物品的体积会影响影子的清晰度

The size of the item affects the sharpness of the shadow

C 物品的形状会影响影子的清晰度

The shape of the item affects the sharpness of the shadow

D 物品的质量会影响影子的清晰度

The mass of the item affects the sharpness of the shadow

9. 培胜透过一片毛玻璃就能看到模糊的书本。如果培胜将 12 片毛玻璃叠在一起，将会怎么样?

Pei Sheng could see the blurred book through a piece of frosted glass. What would happen if Pei Sheng stacked 12 pieces of frosted glass together?

5.1/LS5.1.3/PS5 (HOTs)

A 看不到书本

Can't see the book

B 看到清晰的书本

Can see the books clearly

C 看到模糊的书本

Can see the books blurrily

D 看到体积变大的书本

Can see the books with bigger size

10. 拓明用手电筒照射一个篮球。哪项能影响影子的大小?

To Ming uses the torchlight to shine on a basketball. Which statement affects the size of the shadow?

5.1/LS5.1.3/PS5 (HOTs)

A 篮球的形状

The shape of basketball

B 篮球的款式

The brand of basketball

C 篮球的质量

The mass of basketball

D 篮球与手电筒的距离

The distance between basketball and torchlight

11. 图 3 显示一个箱子和手电筒照射的方向。

Diagram 3 shows a box and the direction of the flashlight.

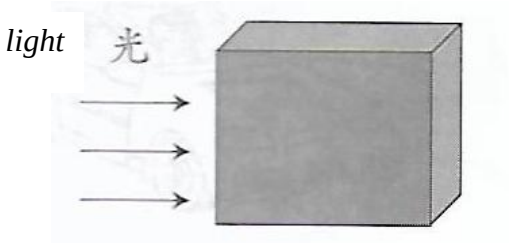


图 3

Diagram 3

哪项是手电筒照射箱子后所出现的影子?

Which one of the shadows appears when the torchlight shines on the box?

5.1/LS5.1.3/PS5 (HOTs)

A 

B 

C 

D 

12. 下面是有心悦进行实验时所作出的推断。

The following are the inferences made by Xin Yue when conducting the experiment.

物体和屏幕的距离会影响影子的面积。 The distance between the object and the screen affects the area of the shadow.

根据心悦的实验，可作出什么假设?

What hypothesis can be made based on Xin Yue's experiment?

5.1/LS5.1.4/PS5 (HOTs)

A 物体和屏幕的距离越近，影子越小。

The closer the object is to the screen, the smaller the shadow.

B 物体和屏幕的距离越远，影子越小。

The farther the object is from the screen, the smaller the shadow is.

C 物体和屏幕的距离越近，影子越大。

The closer the object is to the screen, the larger the shadow is.

D 物体和屏幕的距离越远，影子的面积保持不变。

The farther the object is from the screen, the area of the shadow remains the same.

13. 国杰进行一项实验。他用手电筒和相框之间以不同的距离照射，并记录影子的长度。表 2 显示实验结果。

Guo Jie conducts an experiment. He shines at different distances between the torchlight and the photo frame, and then records the length of the shadows. Table 2 shows the experimental result.

手电筒和相框的距离 **Distance between torchlight and photo frame**	**影子的长度** **length of shadow**
5 cm	20 cm
10 cm	15 cm
15 cm	10 cm

表 2

Table 2

国杰设置手电筒和相框之间的距离是 20 cm。预测影子的长度。

Guo Jie set the distance between the torchlight and the photo frame to 20 cm. Predict the length of the shadow.

5.1/LS5.1.4/PS5 (HOTs)

A 2 cm

B 3 cm

C 4 cm

D 5 cm

14. 什么是光的折射?

What is refraction of light?

5.3/LS5.3.1/PS1

A 光沿着直线传播

Light travels in straight lines

B 影响影子大小和形状的因素

Factors affecting shadow size and shape

C 光照射在物体时改变传播的方向

Changes the direction of propagation when light hits an object

D 光从一种介质进入另一个介质时，传播方向发生偏折

When light passes from one medium to another, the direction of propagation is deflected

15. 图 5 显示一个光的射线图。

Figure 5 shows a ray diagram of light

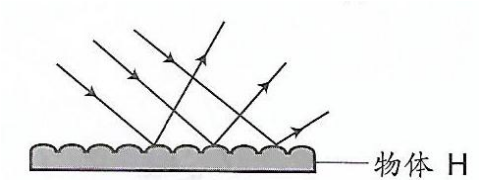


图 5 *Object H*

Diagram 5

哪项可代替物体 H?

Which object can replace object H?

5.2/LS5.2.2/PS3

A 木板

Plank

B 镜子

Mirror

C 黄金

Gold

D 钢铁

Steel

16. 哪项物品是应用光的折射原理制成的?

Which item is made by applying the principle of refraction of light?

5.3/LS5.3.2/PS4

A 潜水镜

Diving goggles

B 防盗镜

Anti-theft mirror

C 放大镜

Magnifying glass

D 口腔镜

Dental mirror

17. 汽车内的倒后镜是应用光的反射原理制成的。如果汽车内没有倒后镜，将会怎样?

The rear mirror in the car is made by applying the principle of reflection of light. What would happen if there were no rear mirrors in the car?

5.2/LS5.3.2/PS4

A 司机无法看到前面的汽车

The driver cannot see the car in front

B 司机无法看到左边的汽车

The driver cannot see the car on the left

C 司机无法看到右边的汽车

The driver cannot see the car on the right

D 司机无法看到后面的汽车

The driver cannot see the car behind

18. 图 6 显示诗琪从水面上观察水里的石头。

Diagram 6 shows Shi Qi observing the stones in the water from the surface?

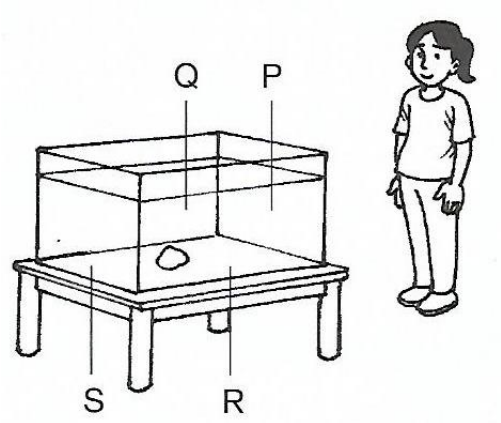


图 6

Diagram 6

哪项是诗琪从水面上观察到的石头位置?

Which is the position of the stone observed by Shi Qi from the water?

5.3/LS5.3.2/PS4

A P

B Q

C R

D S

课题 *Topic*：

能 *Energy*

1. 图 1 显示一种能的来源。

   Diagram 1 shows a source of energy.

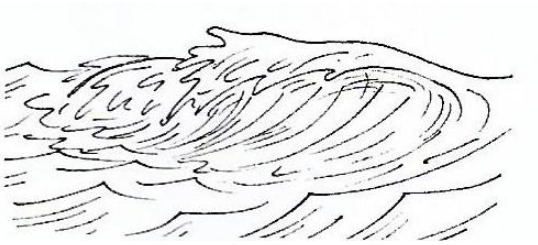


图 1

Diagram 1

哪项是图 1 的能的来源？

Which one is the source of the energy in Diagram 1?

7.1/LS7.1.2/PS1

A 风

Wind

B 太阳

Sun

C 海浪

Wave

D 核燃料

Nuclear Fuel

2. 下面是有关能源 K 的说明。

The following is a description of energy K.

能源 K 在燃烧时会释放能量。 *Energy K releases energy when burned.*

能源 K 最有可能是什么？

What energy K is most likely to be?

7.1/LS7.1.2/PS2

A 水

Water

B 风

Wind

C 生物质

Biomass

D 化石燃料

Fossil Fuel

3. 图 2 显示一个分类图。

Diagram 2 shows a classification diagram.

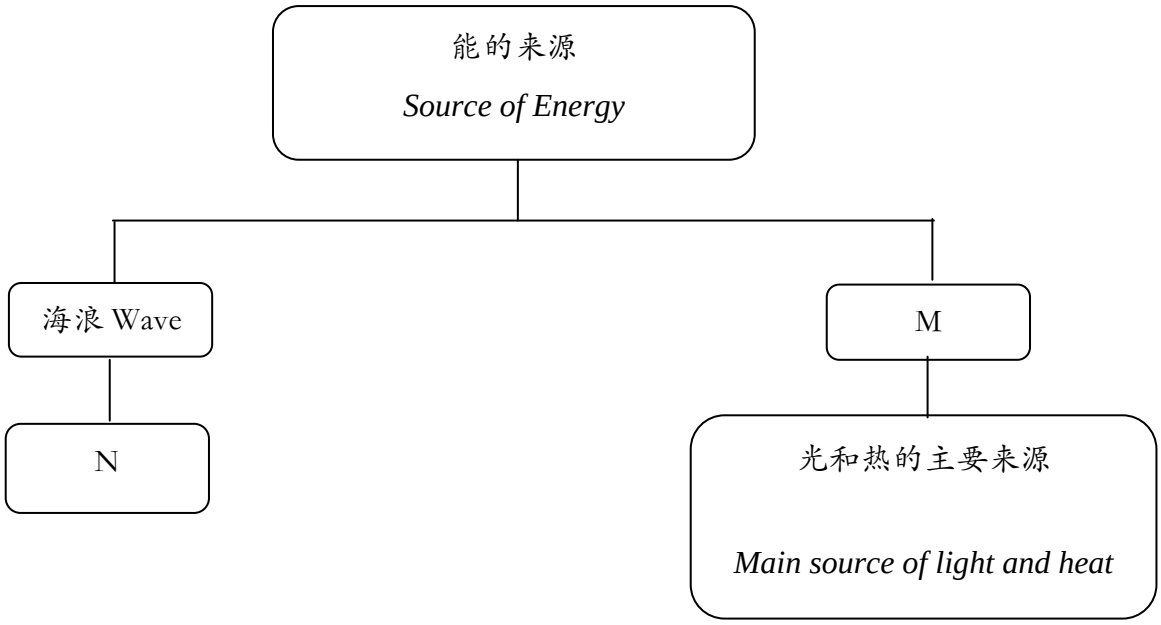


图 2

Diagram 2

M 和 N 代表什么?

Which part of the plant can reduce air resistance?

7.1/LS7.1.2/PS4

	M	N
A	太阳 *Sun*	因涨落可提供能量 *Energy provided by high and low tide*
B	水 *Water*	光和热的主要来源 *Main source of light and heat*
C	海浪 *Wave*	燃烧时可提供能量 *Provides energy when burned*
D	生物质 *Biomass*	因核聚变而产生能量 *Energy generated by nuclear fusion*

4. 图 3 显示两个活动。

Diagram 2 shows a plant.

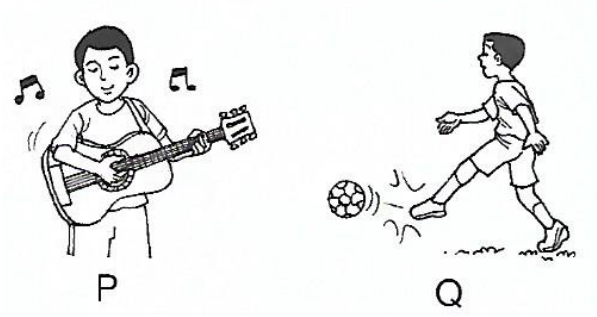


图 3

Diagram 3

活动 P 和活动 Q 具备什么能?

What kind of energy Activity P and Activity Q have?

7.1/LS7.1.4/PS1

	P	Q
A	动能 *Kinetic energy*	势能 *Potential energy*
B	热能 *Heat energy*	化学能 *Chemical energy*
C	声能 *Sound energy*	动能 *Kinetic energy*
D	势能 *Potential energy*	热能 *Heat energy*

5. X 的物体震动后所产生的能量。X 是什么？

The energy produced by the vibration of an object X. What is X?

7.1/LS7.1.3/PS1

A 热能

Heat energy

B 声能

Sound energy

C 动能

Kinetic energy

D 势能

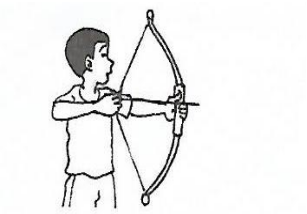
Potential energy

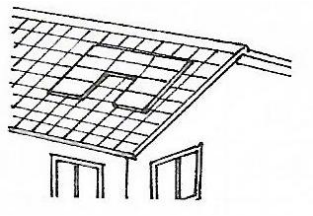
6. 哪个活动具备势能？

Which activity possess potential energy?

7.1/LS7.1.3/PS1

A 

B 

C 

D 

7. 图 4 显示鸿翔将厨余收集起来。

Diagram 4 shows Hong Xiang collecting food waste.

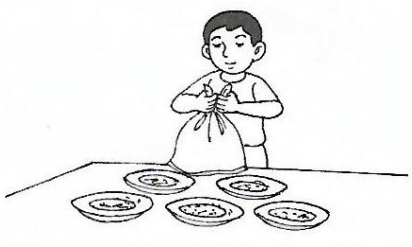


图 4

Diagram 4

厨余是哪一种能源？

What kind of energy is food waste?

7.1/LS7.1.2/PS2

A 势能

Potential energy

B 动能

Kinetic energy

C 化学能

Chemical energy

D 生物质

Biomass

8. 植物通过光合作用将能量储存起来。哪项是植物的能的转换?

Plants store energy through photosynthesis. Which is the energy conversion of plants?

7.1/LS7.1.4/PS3

A 光能 ⟶ 化学能

Light energy ⟶ *Chemical energy*

B 太阳能 ⟶ 热能

Solar energy ⟶ *Heat energy*

C 化学能 ⟶ 太阳能

Chemical energy ⟶ *Solar energy*

D 太阳能 ⟶ 化学能

Solar energy ⟶ *Chemical energy*

9. 下面是有关物品 L 的能的转换。

The following is the energy conversion of the item L.

电能 ⟶ 动能 + 热能
Electricity energy ⟶ *Kinetic energy + Heat energy*

哪项是物品 L?

Which is item L?

7.1/LS7.1.4/PS5 (HOTs)

A 收音机

Radio

B 微波炉

Oven

C 电风扇

Electrical fan

D 电视机

Television

10. 哪项活动的能的转换是势能转换成动能?

Which activity converts potential energy to kinetic energy?

7.1/LS7.1.4/PS5 (HOTs)

A 跑步

Running

B 划船

Rowing boat

C 溜滑梯

Playing slide

D 骑自行车

Riding bicycle

11. 哪项有关能的说明是正确的?

Which statement about energy is correct?

7.1/LS7.1.5/PS5 (HOTs)

A 能可被消灭

Energy can be destroyed

B 能可被创造

Energy can be created

C 能只有一种形式

There is only one type of energy

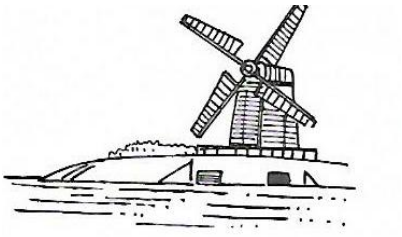
D 能可从一种形式转换至另一种形式或多种形式

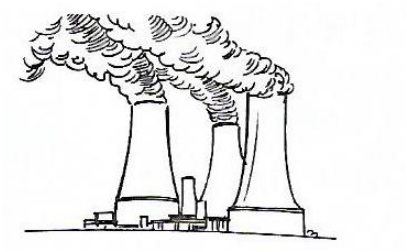
Energy can be transformed from one type to another or multiple types of energy

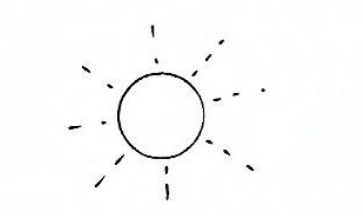
12. 哪项是不可更新的能源?

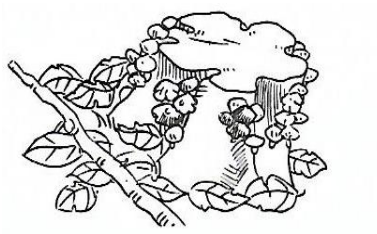
Which one is non-renewable energy?

7.2/LS7.2.1/PS2

A 

B 

C 

D 

13. 哪项是人类进食后，食物在人体中能的转换?

Which is the energy conversion of food in the human body after eating?

7.1/LS7.1.4/PS5 (HOTs)

A 热能 ⟶ 化学能

Heat energy ⟶ *Chemical energy*

B 热能 ⟶ 动能 + 化学能

Heat energy ⟶ *Kinetic energy* + *Chemical energy*

C 化学能 ⟶ 动能 ⟶ 热能

Chemical energy ⟶ *Kinetic energy* ⟶ *Heat energy*

D 化学能 ⟶ 热能 ⟶ 动能

Chemical energy ⟶ *Heat energy* ⟶ *Kinetic energy*

14. 哪项是石油能源的优点?

Which is the advantage of petroleum?

7.2/LS7.2.2/PS4

A 会被耗尽

Will be exhautsed

B 不能被补充

Cannot be replenished

C 会排出废气

Can emit exhaust gas

D 交通工具的燃料

Fuel for transportation

15. 图 5 显示一种能源。

Diagram 5 shows an energy source.

7.2/LS7.2.2/PS1

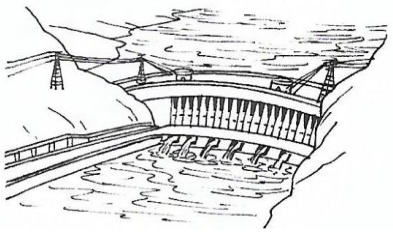


图 5

Diagram 5

哪种能源和图 5 的能源归类在同一组?

Which energy is grouped in the same group as the energy in Diagram 5?

A 煤

Coal

B 石油

Petroleum

C 海浪

Wave

D 天然气

Natural gas

16. 图 6 显示一种能源。

Diagram 6 shows an energy source.

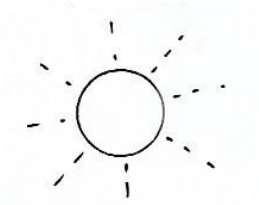


图 6

Diagram 6

哪项有关图 6 的说明是正确的?

Which statement about Diagram 6 is correct?

7.2/LS7.2.1/PS2

A 会污染环境

Will pollute the environment

B 是一种声能

Is a kind of sound energy

C 是不可更新的能源

Is non-renewable energy

D 会产生光能和热能

Will produce light energy and heat energy

17. 哪项是明智地使用不可更新的能源的方法?

Which is the smart way to use non-renewable energy?

7.2/LS7.2.2/PS4

A 乘搭公共交通

Take public transport

B 不控制用水量

Not controlling water consumption

C 24 小时开着冷气机

Switch on air-conditioner for 24 hours

D 长时间开着电冰箱

Open the refrigerator for a long time

18. 图 7 显示艺峰冲凉后所作出的一项举动。

Diagram 7 shows one of Yi Feng's actions after taking a shower.

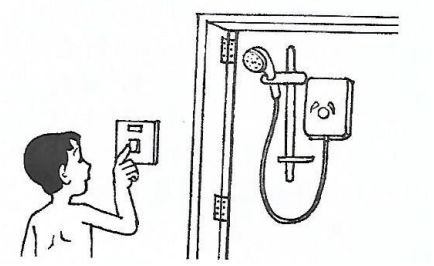


图 7

Diagram7

为什么艺峰要作出图 7 的举止?

Why does Yi Feng behave like in Diagram 7?

7.2/LS7.2.2/PS4

A 减少电费开销

Reduce electricity bills

B 避免造成环境污染

Avoid environmental pollution

C 避免更换新的灯泡

Avoid changing to new bulbs

D 避免灯泡的开关损坏

Avoid damage to the switch of the light bulb

19. 下面是有关矿物 P 的说明。

Below is the description of the mineral P.

矿物 P 蕴藏在地底下。当它被挖掘出来后，可用来生火煮食和推动机械。一旦用完了，再也无法被补充。 *The mineral P is stored underground. When it is excavated, it can be used to make fires for cooking and to propel machinery. Once used up, it can no longer be replenished.*

哪项最有可能是矿物 P?

Which is most likely to be the mineral P?

7.2/LS7.2.2/PS2

A 铜

Copper

B 煤

Coal

C 银

Silver

D 黄金

Gold

20. 为什么我们要不断研发更多新的能源?

Why do we keep developing more new energy sources?

7.2/LS7.2.2/PS4

A 为国争光

Win glory for the country

B 赚取暴利

Make huge profits

C 响应环保

Respond to environmental protection

D 能源会耗尽

Energy source will be run out.

课题 *Topic*：

材料 *Material*

1. 图 1 显示一种物品。

   Diagram 1 shows one item.



图 1

Diagram 1

哪项是图 1 物品的制造材料?

Which is the material of manufacture for the item in Diagram 1?

8.1/LS8.1.1/PS1

A 棉

Cotton

B 橡胶

Rubber

C 皮革

Leather

D 木材

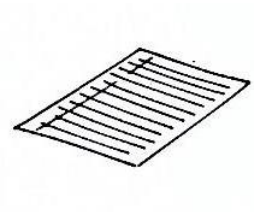
Wood

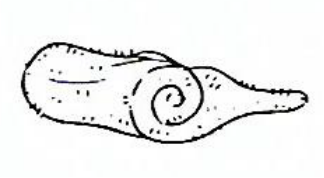
2. 哪种物品是用丝来制造?

Which item is made of silk?

8.1/LS8.1.1/PS1

A 

B 

C 

D 

3. 图 2 显示两种物品，K 和 L。

Diagram 2 shows two items, K and L.

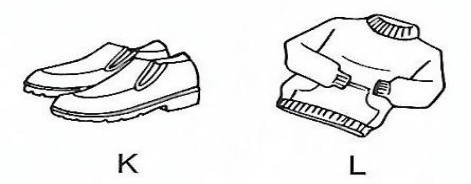


图 2

Diagram 2

哪项能和图 2 的物品归类在一起?

Which item can be grouped with the item in Diagram 2?

8.1/LS8.1.2/PS3

A 气球

Balloon

B 裤带

Belt

C 水桶

Pail

D 桌子

Table

4. 下面是四种不同的材料。

Below are four different materials.

P 丝 *P Silk*	Q 皮革 *Q Leather*
R 棉 *R Cotton*	S 木材 *S Wood*

哪项的材料源自植物?

Which material is derived from plants?

8.1/LS8.1.1/PS1

A P 和 Q

P and Q

B P 和 R

P and R

C Q 和 R

Q and R

D R 和 S

R and S

5. 图 3 显示一个分类图。

Figure 3 shows a classification diagram.

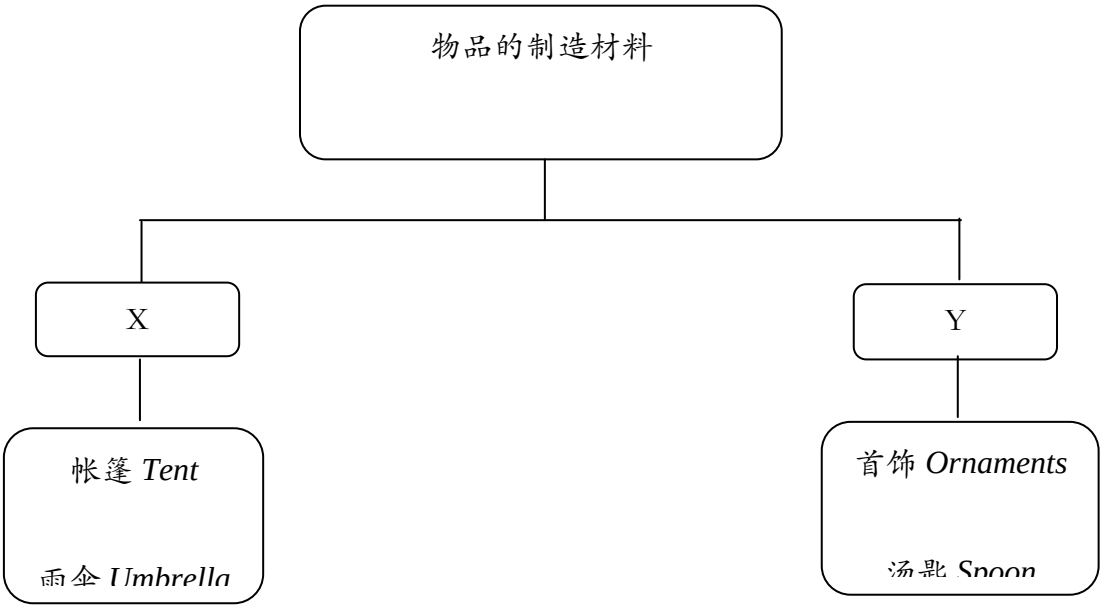


图 3

Diagram 3

哪项能代表 X 和 Y?

Which term can represent X and Y?

8.1/LS8.1.2/PS3

	X	Y
A	玻璃 *Glass*	人造布料 *Artificial Fabric*
B	皮革 *Leather*	塑料 *Plastic*
C	人造布料 *Artificial Fabric*	金属 *Metal*
D	土壤 *Soil*	木材 *Wood*

6. 图 4 显示一种物品。

Diagram 4 shows one item.



图 4

Diagram 4

哪项是图 4 物品的制造材料的来源?

Which is the source of the materials for the manufacture of the item in Diagram 4?

8.1/LS8.1.1/PS1

A 石油

Petroleum

B 植物

Plants

C 动物

Animals

D 岩石

Rock

7. 图 5 显示一种原料。

Diagram 5 shows a raw material.



图 5

Diagram 5

图 5 的原料可以制成哪一种物品?

What kind of items can be made from the raw material in Diagram 5?

8.1/LS8.1.1/PS2

A 扳手

Wrench

B 手链

Bracelet

C 塑料袋

Plastic bag

D 手提包

Handbag

8. 图 6 显示两种物品，Y 和 Z。

Diagram 6 shows two item, Y and Z.

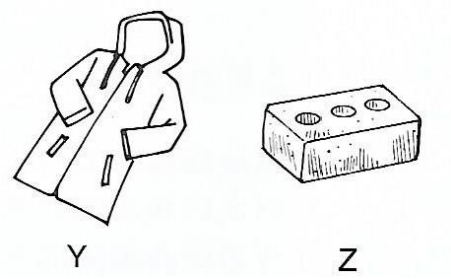


图 6

Diagram 6

物品 Y 和物品 Z 的制造材料是什么?

What are the manufacture materials of item Y and item Z?

8.1/LS8.1.2/PS3

	Y	Z
A	金属 *Metal*	玻璃 *Glass*
B	皮革 *Leather*	人造布料 *Artificial Fabric*
C	木材 *Wood*	塑料 *Plastic*
D	人造布料 *Artificial Fabric*	土壤 *Soil*

9 哪项是以塑料所制成的物品特性?

Which characteristic is an item made of plastic??

8.2/LS8.2.2/PS2

A 吸水

Absorb water

B 不透明

Opaque

C 不透水

Waterproof

D 非常坚硬

Very hard

10. 哪项的搭配是正确的?

Which combination is correctly matched?

8.2/LS8.2.3/PS5 (HOTs)

	吸水 ***Absorb Water***	**不透水** *Waterproof*
A	雨衣 *Raincoat*	丝绸 *Silk*
B	毛巾 *Towel*	吸管 *Straw*
C	水桶 *Pail*	海绵 *Sponge*
D	茶壶 *Teapot*	帐篷 *Tent*

11. 下面是有关物品 J 的特性。

The following are the properties of item J.

8.2/LS8.2.3/PS4

- 吸水

  Absorb water

- 没有弹性

  Inelastic

- 热的绝缘体

  Heat insulator

哪项最有可能是物品 J?

Which is most likely to be item J?

A 戒指

Ring

B 纸鹤

Paper crane

C 橡皮擦

Eraser

D 塑料盒

Plastic box

12. 图 7 显示橡皮擦掉在地上的情况。

Diagram 7 shows the eraser falling to the ground.

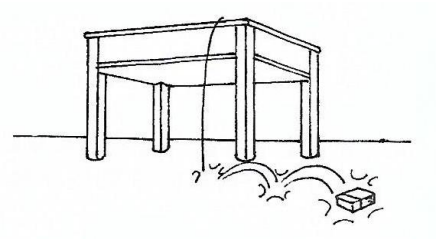


图 7

Diagram 7

8.2/LS8.2.4/PS5 (HOTs)

图 7 的情况说明了什么?

What does the situation in Figure 7 show?

A 橡皮擦是固体

Eraser is solid

B 橡皮擦不透水

Eraser is waterproof

C 橡皮擦有弹性

Eraser is elastic

D 橡皮檫电的绝缘体

Eraser is electrical insulator

13. 哪个物品无法让光线透过?

Which item cannot let light through?

8.2/LS8.2.1/PS5 (HOTs)

A 窗口

Window

B 刀片

Blade

C 绘画纸

Drawing paper

D 塑料袋

Plastic bag

14. 俊杰准备将物体 J 和物体 K 连接电路时，发现连接物体 J 后灯泡会发亮，而连接物体 K 后灯泡没有发亮。哪项最有可能是物体 J 和物体 K?

When Jun Jie was about to connect object J and object K to the circuit, he found that the light bulb would light up after connecting object J, but the light bulb would not light up after connecting object K. Which term is most likely to be object J and object K?

8.2/LS8.2.3/PS5 (HOTs)

	J	**K**
A	硬币 *Coin*	黏土 *Clay*
B	木尺 *Wooden Ruler*	砖块 *Brick*
C	刀片 *Blade*	回形针 *Paper Clip*
D	手帕 *Handkerchief*	扳手 *Wrench*

15. 图 8 显示一种厨房用具。

Diagram 8 shows a kitchen appliance.

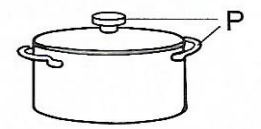


图 8

Diagram 8

部分 P 的制作材料必须具备什么特点?

What characteristics must be possessed by the material for making part P?

8.2/LS8.2.2/PS5 (HOTs)

A 会吸水

Absorb water

B 透明体

Transparent

C 导电体

Electrical conductor

D 不导热

Heat insulator

16. 黄先生准备到冬天的国家旅游。哪种材料制成的衣服适合他带去旅游?

Mr. Wong is going to travel to the country in winter. What kind of clothes is suitable for him to take on travel?

8.2/LS8.2.3/PS5 (HOTs)

A 丝

Silk

B 橡胶

Rubber

C 人造布料

Artificial Fabric

D 人造皮革

Artificial Leather

17. 哪项物品的制作材料能浮在水面上?

Which item's manufacture material can float on water?

8.2/LS8.2.3/PS5 (HOTs)

A 轮胎

Tyre

B 钥匙

Key

C 项链

Necklace

D 硬币

Coin

18. 图 9 显示一种日常物品，M。

Diagram 9 shows a daily item, M.



图 9

Diagram 9

如果物品 M 是以吸水的材料制成，将会怎样?

What if the item M is made of a material that absorbs water?

8.2/LS8.2.3/PS5 (HOTs)

A 物品 M 更耐用

Item M is more durable

B 物品 M 更耐热

Item M is more heat resistant

C 物品 M 会膨胀

Item M will expand

D 物品 M 无法盛装饮料

Item M cannot hold drinks

19. 哪项有关材料性质的说明是正确的?

Which statement about the properties of a material is correct?

8.2/LS8.2.4/PS5 (HOTs)

A 金属制成的物品无法吸取热能

Items made of metal cannot absorb heat

B 木材制成的物品能让电流通过

Items made of wood allow electricity to pass through

C 有浮力的物品无法沉入水里

Buoyant objects cannot sink in water

D 透明体能吸收大量水分

Transparent object can absorb a lot of water

20. 图 10 显示一个饭锅。

Diagram 10 shows a rice cooker.



图 10

Diagram 10

为什么部分 G 是以塑料制成的?

Why part G is made of plastic?

8.2/LS8.2.3/PS5 (HOTs)

A 避免被烫伤

Avoid from getting burned

B 避免被电到

Avoid from getting electrocuted

C 部分 G 不透水

Part G is waterproof

D 方便人们拿起来

Convenient for people to pick up

四年级科学

Year 4 Science

后测

Post-Test

姓名： **班级：** **分数：**

Name: _____ **Class**: _____ **Mark**: _____

时间： 1 小时

Duration: 1 hour

乙组

Section B

（90%）

指示 Instruction:

- 本文包含 12 个开放性问题。

  This paper contains 4 open-ended questions.
- 你必须**回答所有问题**。

  *You are required to **answer all the questions**.*
- 所有答案必须写在纸上。

  All the answers must be written in the paper.
- 一旦你倾向于更改答案，请清除原本答案并写下新答案。

  Once you tend to change the answer, erase the original answer clearly and write the new answer.

课题 *Topic*：

光的特征 *Properties Of Light*

1. 图1显示良友把P、Q和R三个相同的物体放在与光源不同的距离，然后按亮光源，并观察和记录银幕上出现的影子。图1显示他的记录结果。

Diagram 1 shows that Liang You placed three identical objects P, Q and R at different distances from the light source, then pressed the light source, observed and recorded the shadows appearing on the screen. Diagram 1 shows his recorded results.

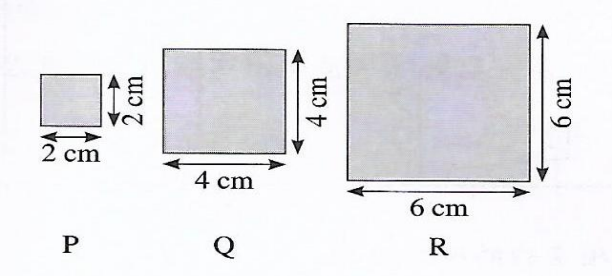


图1

Diagram 1

a) 根据这项实验的变数，

According to the variables of this experiment,

5.1/LS5.1.4/PS4

i. 固定性变数：_____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

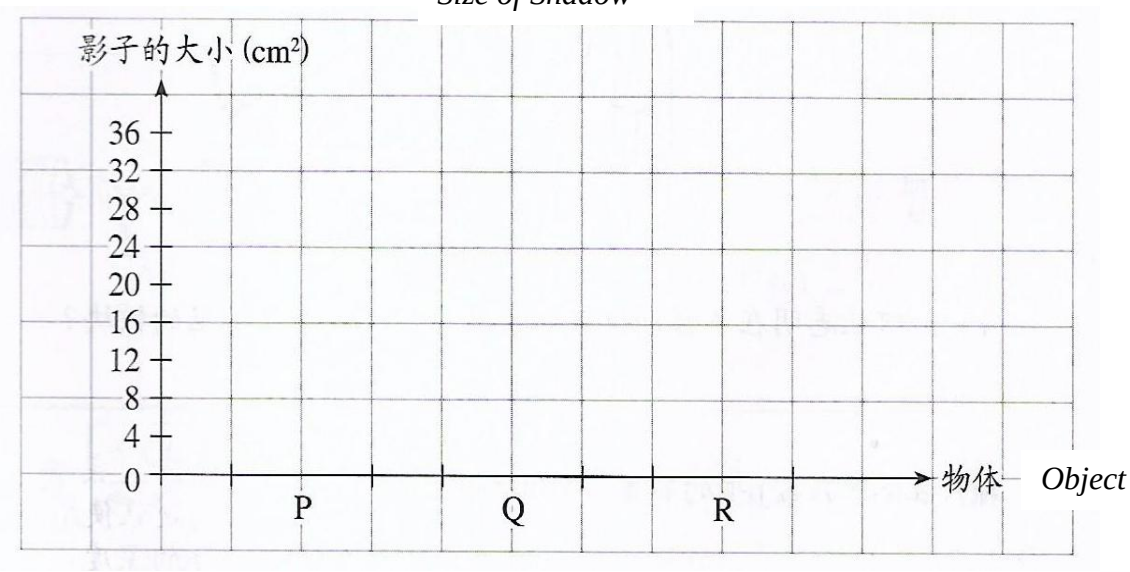
【3分】

[3 marks]

b) 根据图 1 的观察结果，绘制一个条形统计图来显示物体所形成的影子的大小。 *Based on the observations in Diagram 1, draw a bar graph showing the size of the shadow formed by the object.*

5.1/LS5.1.3/PS5 (HOTs)

Size of Shadow



【3 分】

[3 marks]

2. 图 2.1 显示一组学生各别把两个玩具熊放在 X 物体和 Y 物体前，然后观察物体的表面所出现的影像。

Diagram 2.1 shows a group of students placing two teddy bears in front of the X object and the Y object respectively, and then observe the image that appears on the surface of the object.

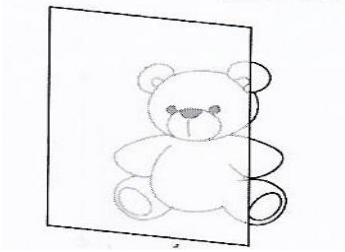
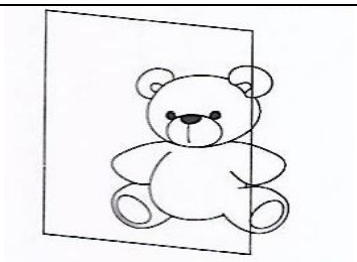
X 物体 *Object X*	Y 物体 *Object Y*
	

图 2.1

Diagram 2.1

a) 写出这项实验的观察结果。

Write down the observations of this experiment.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2 分】

[2 marks]

b) 如果用木板取代 Y 物体，预测学生的观察结果。

If object Y is replaced with a plank, predict the student's observations.

5.1/LS5.1.4/PS6 (HOTs)

_____

【2分】

[2 marks]

图 2.2 显示志明无法看到碗里的铁块。

Diagram 2.2 shows that Zhi Ming can't notice the iron in the bowl.

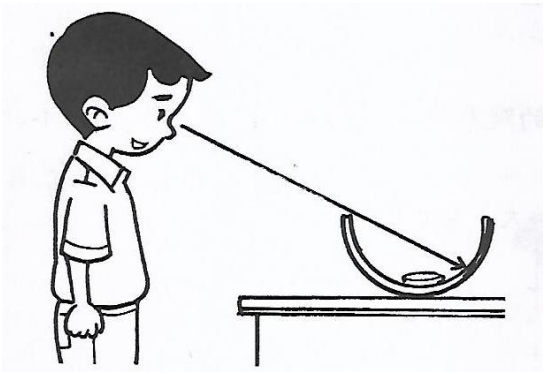


图 2.2

Diagram 2.2

c) 如何让志明在不移动位置的情况下，可以看见碗里的铁块?

How to make Zhi Ming notice the iron in the bowl without moving his position?

5.1/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

d) 根据你在（c）项的答案，作出解释。

Give an explanation based on your answer in (c).

5.3/LS5.3.2/PS6 (HOTs)

_____

【2 分】

[2 marks]

e) 相关的方法，与光的哪种特征有关?

Referring to the method used, which feature of light is related to?

5.3/LS5.3.1/PS4

_____

【2 分】

[2 marks]

3.

a) 图 3.1 显示小萍进行的一项实验。

Diagram 3.1 shows an experiment conducted by Xiao Ping.

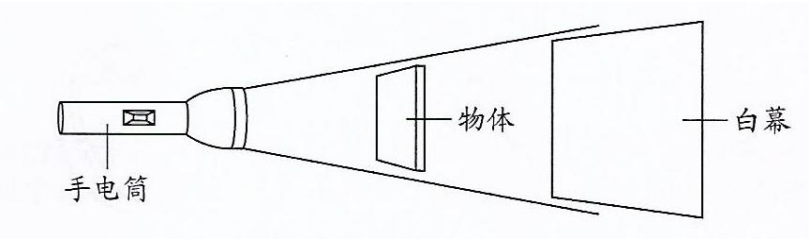


图3.1

Diagram 3.1

表 3 显示她的观察结果。

Table 3 shows her observations.

手电筒与物体的距离（cm） *Distance between torchlight and object (cm)*	50	40	30
影子的大小（cm） *Size of shadow (cm)*	10	15	20

表 3

Table 3

i) 写出这项实验中的操纵性变数。

Write the manipulated variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

ii) 写出这项实验中的反应性变数。

Write the responding variable in this experiment.

5.1/LS5.1.3/PS4

_____

【1分】

[1 mark]

iii) 写出操纵性变数与反应性变数之间的一个关系。

Write one relationship between manipulative variable and responding variable.

5.1/LS5.1.3/PS4

_____

【2分】

[2 marks]

b) 图 3.2 显示光线射向一面镜子。

Diagram 3.2 shows light hitting a mirror.

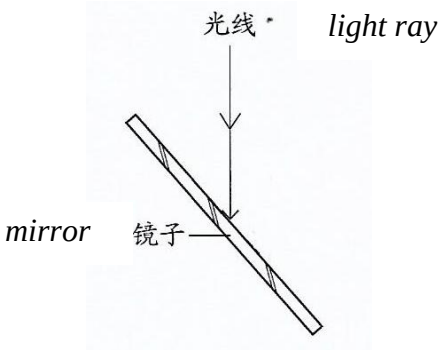


图 3.2

Diagram 3.2

在图 3.2 画出光的射线图。

Draw the ray diagram of light in Diagram 3.2.

5.2/LS5.2.3/PS2

【2 分】

[2 marks]

4. 图 4.1 显示两种用具。

Diagram 4.1 shows two appliances.

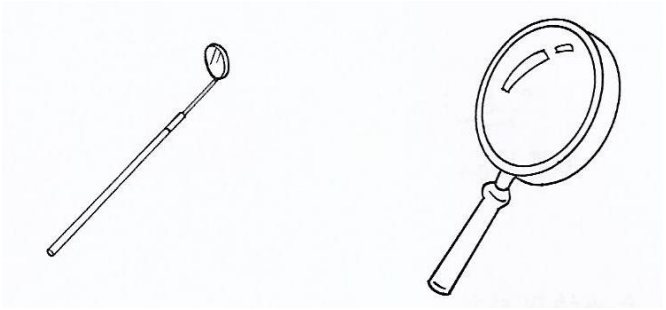


图 4.1

Diagram 4.1

a) 上述工具应用了什么光的特性?

What light properties are applied to the above tools?

5.2/LS5.2.2/PS3

i. 口腔镜：_____

Dental mirror: _____

5.3/LS5.3.2/PS3

ii. 放大镜：_____

Magnifying glass: _____

【2分】

[2 marks]

b) 根据 (a) 项的答案，说明该工具如何使用光的特性来操作。

Based on your answer to (a), explain how the tool uses the properties of light to operate.

5.2/LS5.2.2/PS6 (HOTs)

i. 口腔镜：_____

Dental mirror: _____

【2 分】

[2 marks]

5.3/LS5.3.2/PS6 (HOTs)

ii. 放大镜：_____

Magnifying glass: _____

【2 分】

[2 marks]

c) 图 4.2 显示一台显微镜。

Diagram 4.2 shows a microscope.

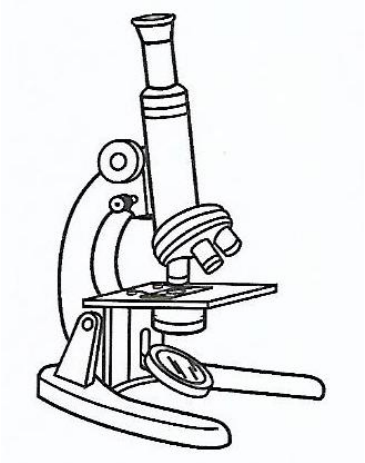


图 4.2

Diagram 4.2

把使用光的反射原理的部分标为 X。使用光的折射原理的部分标为 Y。

The part that uses the principle of reflection of light is marked with 'X'. The part that uses the principle of refraction of light is marked as 'Y'.

5.3/LS532.2/PS6 (HOTs)

【2分】

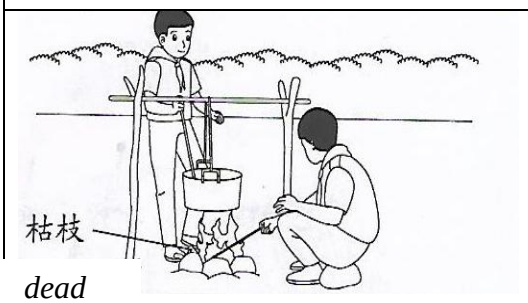
[2 marks]

课题 *Topic*：

能 *Energy*

1. 图 1 显示两组童子军用不同的能源来烹煮食物。

Diagram 1 shows two teams of Boy Scouts using different energy sources to cook food.

S 组 *Team S*	T 组 *Team T*
	

dead

natural

图 1

Diagram 1

a) S组和T组童子军各别使用什么能源来煮食?

What kind of energy source do the boy scouts of Team S and Team T use to cook food?

7.1/LS7.1.2/PS1

iii. S 组：_____

Team S: _____

iv. T 组：_____

Team T: _____

【2 分】

[2 marks]

b) 他们所使用的能源不同，但所涉及的能的转换却是相同的。写出相关的能的转换。

The energy they use is different, but the conversion of energy involved is the same. Write the energy transformation.

7.1/LS7.1.4/PS3

【
2

【2 分】

[2 marks]

c) 他们所使用的属于哪种能源？在空格里填写代表童子军的英文字母。

What kind of energy they use? Fill in the blanks with English letters representing Boy Scouts.

7.2/LS7.2.1/PS2

i) 不可更新的能源 *Non-renewable energy*	ii) 可更新的能源 *Renewable energy*

【1分】

[1 mark]

d) 你会鼓励他们使用哪种能源?

Which energy source would you encourage them to use?

7.2/LS7.2.1/PS2

不可更新的能源 *Non-renewable energy*	
可更新的能源 *Renewable energy*	

【1分】

[1 mark]

写出你的原因。

Write your reason.

7.2/LS7.2.1/PS2

_____

【1分】

[1 mark]

2.

a) 什么是能?

What is energy?

7.1/LS7.1.1/PS1

_____

【2分】

[2 marks]

b) 图2.1显示妹妹在溜滑梯上。

Diagram 2.1 shows the sister on the slide.

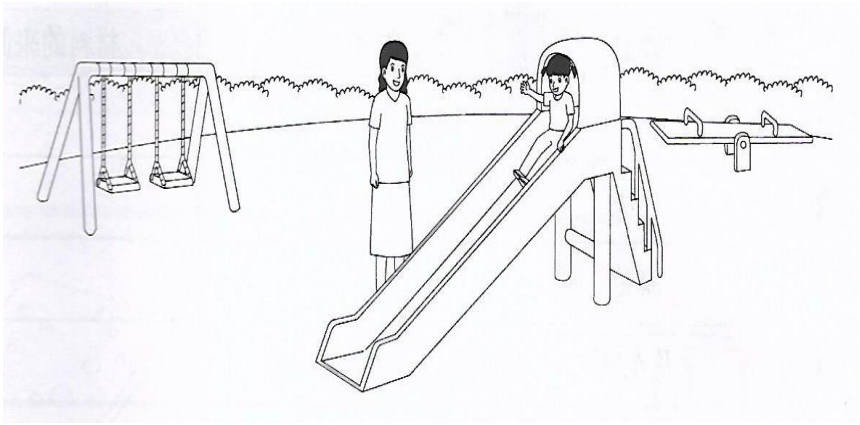


图2.1

Diagram 2.1

i. 妹妹在滑梯上具有什么形式的能?

What kind of energy does my sister have on the slide?

7.1/LS7.1.3/PS1

_____

【1分】

[1 mark]

ii. 当妹妹从滑梯上溜下来，能的形式会转换吗?

When the sister slips down the slide, will the form of energy change?

7.1/LS7.1.4/PS3

会 *Yes*	
不会 *No*	

【1分】

[1 mark]

根据你在（b）（ii）项的答案，写出能的形式转换。

According to your answer in (b)(ii), write the energy that can be converted.

7.1/LS7.1.4/PS3

_____

【2分】

[2 marks]

c) 下面显示X电器操作时能的转换。

The following shows the energy conversion when the appliance X operates.

电能 ⟶ 光能 + 声能 *Electrical energy* ⟶ *Light energy + Sound energy*

X电器是什么？

What is *appliance X*?

7.1/LS7.1.4/PS3

_____

【2分】
[2 marks]

3. 图 3 是两种能的来源，P 和 Q。

Diagram 3 shows two sources of energy, P and Q.

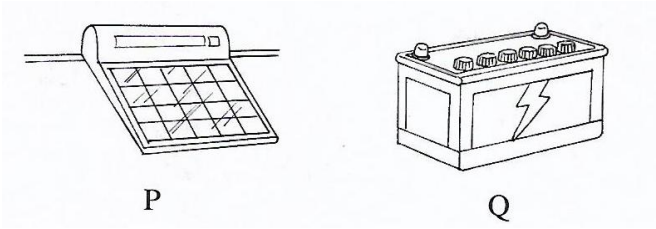


图 3

Diagram 3

(a) i. 你认为我们应该多使用哪种能源？把答案圈出来。

Which energy source do you think we should use more? Circle the answer.

7.2/LS7.2.2/PS4

P	Q

【1 分】

[1 mark]

ii. 写出你的理由。

Write your reason.

7.2/LS7.2.2/PS4

_____

【1 分】

[1 mark]

b) 写出相关的能的转换。

Write down the relevant energy conversion.

7.1/LS7.1.4/PS5 (HOTs)

i. P: _____

ii. Q: _____

【4 分】

[4 marks]

c) 下面是一种能源的资料。选择正确的能源和下面的资料连线。

The following is the information of one energy source. Select the correct energy source and match the information below.

7.1/LS7.1.2/PS2

资料 ***Information***
我源自地底。我可以用来提炼各种燃料。如果人类不懂珍惜我，有一天就会从地球上消失。我是谁? *I come from the underground. I can be used to refine all kinds of fuels. If human beings don't know how to cherish me, I will disappear from the earth one day. Who am I?*

能源 ***Energy***
电池 *Battery*
煤 *Coal*
石油 *Petroleum*

【2 分】

[2 marks]

4. 图 4.1 显示在繁忙的大都市几乎每天都会出现的一种情况。

Diagram 4.1 shows an almost daily situation in a busy metropolis.

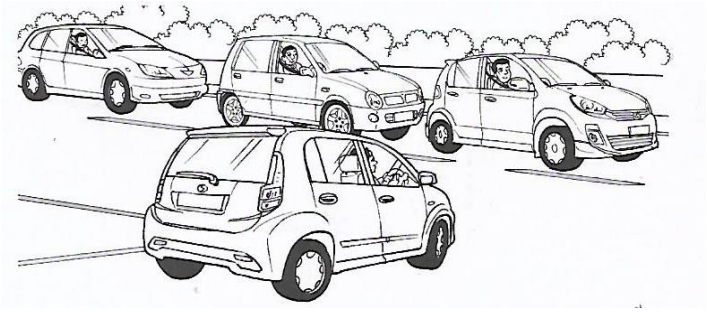


图 4.1

Diagram 4.1

(a) i. 上面的交通工具一般使用什么燃料来驱动?

What fuel do the above vehicles generally use to move?

7.2/LS7.2.2/PS1

_____

【2 分】

[2 marks]

ii. 根据你在2（a）i.的答案，写出该情况对环境造成一个主要负面影响。

Based on your answer in 2(a)i., write that the situation caused a major negative impact on the environment.

7.2/LS7.2.2/PS4)

_____

【2 分】

[2 marks]

(b) 图 4.2 显示子文进行的一项活动。

Diagram 4.2 shows an activity performed by the Zi Wen



图 4.2

Diagram 4.2

写出遥控汽车操作时涉及什么能的形式转换。

Write out what forms of energy conversions are involved in the operation of a remote-control car.

7.1/LS7.1.4/PS5 (HOTs)



【3分】

[3 marks]

课题 *Topic*：

材料 *Material*

1. 图 1 显示 P 和 Q 两种材料的来源。

Diagram 1 shows the sources of both Material P and Q.

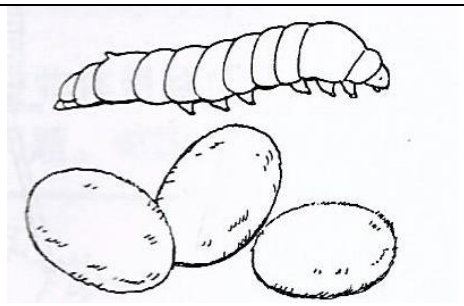
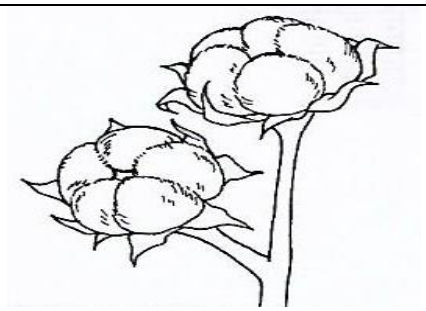
P材料	Q材料
	

图 1

Diagram 1

a) P材料和Q材料各别是什么？

What are materials P and Q?

圈出正确的答案。

Circle the correct answer.

8.1/LS8.1.1/PS1

i)	P材料:	丝	棉
	Material P:	*Silk*	*Cotton*
ii)	Q材料:	丝	棉
	Material Q:	*Silk*	*Cotton*

【2 分】

[2 marks]

c) i) 哪种材料适合来处理餐桌上被倒翻的牛奶?

Which material is suitable for dealing with overturned milk on the table?

8.2/LS8.2.1/PS5 (HOTs)

_____ 材料

Material _____

【2 分】

[2 marks]

ii) 写出你的原因。

Write your reason.

8.2/LS8.2.1/PS5 (HOTs)

_____

【2 分】

[2 marks]

2. 图 2 显示一组学生用本生灯把四个以不同材料制成的容器来加热 250 ml 的水。他们把各个容器里的水沸腾所需的时间记录在表 1 里。

Diagram 2 shows a group of students using a Bunsen burner to heat 250 ml water in four containers made of different materials. They recorded the time it took for the water in each container to boil in Table 1.

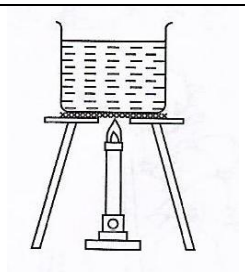
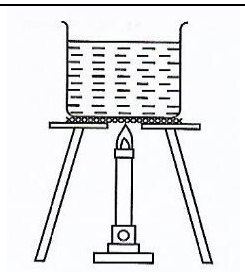
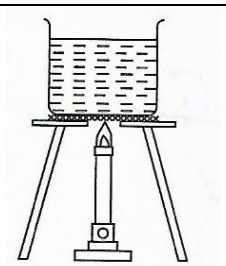
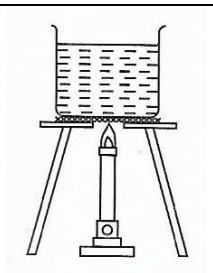
P 容器 *Container P*	Q 容器 *Container Q*	R 容器 *Container R*	S 容器 *Container S*
			

图 2

Diagram 2

容器 ***Container***	**P**	**Q**	**R**	**S**
水沸腾所需的时间（分钟） ***Time taken for the water to boil (minutes)***	2	4	1	3

表 1

Table 1

a) 写出这项实验中的变数。

Write the variables in this experiment.

8.2/LS8.2.4/PS4

i. 固定性变数: _____

Constant Variable: _____

ii. 操纵性变数：_____

Manipulated Variable: _____

iii. 反应性变数：_____

Responding Variable: _____

【3 分】

[3 marks]

b) 根据表1，各个容器里的水沸腾所需的时间不同。

According to Table 1, time taken for the water to boil in each container varies.

材料的什么性质导致这样的结果？圈一圈。

What properties of the material lead to this result? Circle the answer.

8.2/LS8.2.1/PS4

容器的导电能力 *Heat conductivity of the container*	容器的吸水能力 *Water absorption capacity of the container*	容器的导热能力 *Heat conductivity of the container*

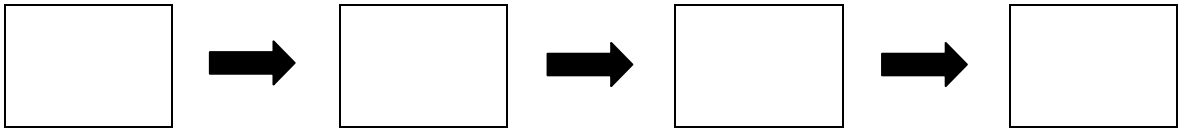
【2 分】

[2 marks]

c) 根据你在（b）项的答案提及的材料性质，由强至弱进行排列。

Rank from the strongest to the weakest order according to the properties of materials you mentioned in your answer to (b).

8.2/LS8.2.1/PS4



【4分】

[4 marks]

d) 写出这项实验中的操作性定义。

Write the operational definition for this experiment.

8.2/LS8.2.4/PS5 (HOTs)

_____

【2 分】

[2 marks]

3. 图 3 显示一项有关物体的材料性质的实验。

Diagram 3 shows an experiment on the material properties of an object.

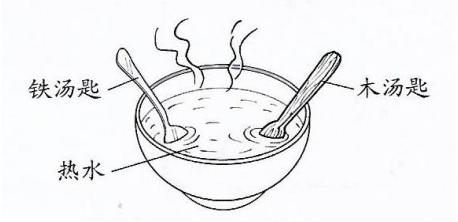


图3

Diagram 3

(a) i. 写出这项实验要测试的材料性质。

Write down the material properties to be tested in this experiment

8.2/LS8.2.4/PS4

_____

【2 分】

[2 marks]

(b) i. 一名学生用 N 汤匙重复上面的实验。他发现 N 汤匙不热。根据材料的性质，N 汤匙可以和哪一汤匙归为同一组？圈出正确的答案。

A student repeats the above experiment with Spoon N. He found that Spoon N was not hot. Depending on the nature of the material, Spoon N can be grouped with which spoon? Circle the correct answer.

8.2/LS8.2.4/PS5 (HOTs)

铁汤匙 *Iron spoon*	木汤匙 *Wooden spoon*

【1 分】

[1 mark]

ii. 写出 N 汤匙的制作材料。

Write down the material of Spoon N.

8.2/LS8.2.4/PS3

_____

【1 分】

[1 mark]

4. a) 图 4. 1 显示材料的来源于相关的例子。在指定的空格里，写上正确的答案，完成图 4.1。

Diagram 4.1 shows an example of the origin of the material. In the designated space, write the correct answer to complete Diagram 4.1.

8.1/LS8.1.2/PS1

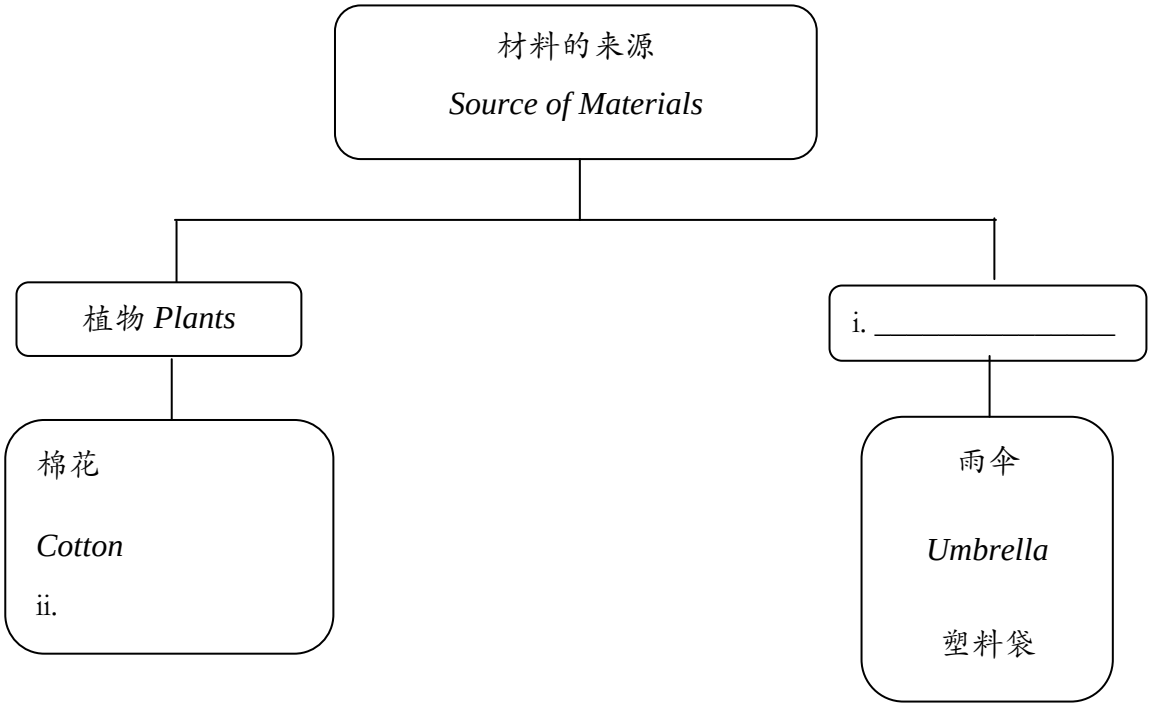


图4.1

Diagram 4.1

【2 分】

[2 marks]

(b)

秀丽想请爸爸帮她在屋外建一个小屋子给她的宠物。针对小屋子的设计，她有两个要求：

Xiu Li wants to ask her father to help her build a small house outside the house for her pet. For the design of the small house, she has two requests:

11. 能看到宠物在屋子里的情况。

Can see the pet in the house.

12. 宠物在屋子里不会日晒雨淋。

The pet will not be exposed to the sun and rain in the house.

针对秀丽的要求，你认为小屋子应该使用具备什么性质的材料来制作？选择正确的材料与小屋子的部分连线。

According to the requests of Xiu Li, what kind of materials do you think the small house should be made of? Choose the correct material to match the house part.

8.2/LS8.2.2/PS5 (HOTs)

小屋子的部分 *Part of Small House*
i. 屋顶 *Roof*
ii. 墙 *Wall*

性质 *Properties*
透明体 *Transparent*
不透明体 *Opaque*
半透明体 *Translucent*

【2 分】

[2 marks]

(c) 图 4.2 显示制造熨斗的各种材料。

Diagram 4.2 shows the various materials from which iron are made.

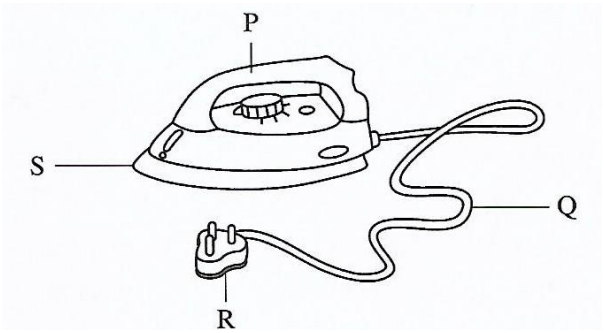


图4.2

Diagram 4.2

i. 哪种材料是热的绝缘体?

Which material is heat insulator?

8.2/LS8.2.1/PS4

_____

【1 分】

[1 mark]

ii. 写出（c）（i）项的材料在熨斗中的用途是什么?

What is the use of the material in item (c)(i) in the iron?

8.2/LS8.2.2/PS5 (HOTs)

_____

【1 分】

[2 marks]

APPENDIX O: First Draft of Questionnaire (PBBG)

Survey Number: _____

Date: _____ / _____ / 22

Time: _____

- .

Universiti Malaysia Sarawak

Faculty of Cognitive Science and Human Development

A COLLABORATIVE LEARNING OF YEAR 4 SCIENCE SUBJECT USING COMPUTERISED BOARD GAMES

There are 45 questions in this questionnaire.

You will spend around 10 – 15 minutes to answer this questionnaire.

本问卷共有 45 个问题。

THIS IS A RESEARCH PROJECT CONDUCTED UNDER FACULTY OF COGNITIVE SCIENCE AND HUMAN DEVELOPMENT UNIVERSITI MALAYSIA SARAWAK TO FULFILL DOCTOR OF PHILOSOPHY RESEARCH

Your answers will be kept confidential.

"Thank you for your cooperation."

你的回答将会被保密。

"谢谢你的合作。"

Section A: Socio-Demographic Characteristics

A 部分：背景问题

Please tick (/) or fill your answer.

请勾选 (/) 或填写您的答案。

1. Age 年龄: _____

2. Class 班级: _____

3. Gender: ( ) Male 男性

   性别 ( ) Female 女性

4. Race: ( ) Malay 马来人 ( ) Chinese 华人

   种族 ( ) Iban 伊班人 ( ) Others 其他: _____

5. Religion: ( ) Muslim ( ) Non-Muslim

   宗教 穆斯林 非穆斯林

Section B: Learning Motivation

B 部分：学习动机

The following questions ask about your motivation for this class. **Remember there are no right or wrong answers, just answer as accurately as possible.** Use the scale below to answer the questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的动机。 **请记住，答案没有对错之分，请尽可能准确地回答**。同时，也请使用下面的量表来回答问题。 如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	1	2	3	4	5
2.	If I study in appropriate ways, I will be able to learn the material of Paper-Based Board Games in Science. 如果我以适当的方式学习，那么我将能够学习纸质版桌游的科学资料。	1	2	3	4	5
3.	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	1	2	3	4	5
4.	I think I can to use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	1	2	3	4	5
5.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成	1	2	3	4	5

	绩。					
6.	I'm certain I can understand the most difficult material presented in the Paper-Based Board Games for Science subject. 我确信我能理解科学科目纸质版桌游中最难的资料。	1	2	3	4	5
7.	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	1	2	3	4	5
8.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	1	2	3	4	5
9.	It is my own responsibility if I do not learn the material in Paper-Based Board Games. 如果我不学习纸质版桌游中的资料，那会是我自己的责任。	1	2	3	4	5
10.	It is important for me to learn Science knowledge in these Paper-Based Board Games. 在这些纸质版桌游中学习科学知识对我来说很重要。	1	2	3	4	5

11.	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	1	2	3	4	5
12.	I'm confident I can learn the basic concepts taught in the Paper-Based Board Games. 我相信我可以学习纸质版桌游中教授的基本概念。	1	2	3	4	5
13.	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	1	2	3	4	5
14.	When I take assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	1	2	3	4	5
15.	I'm confident I can understand the most complex material presented by the teacher in the Paper-Based Board Games.	1	2	3	4	5

	我有信心能听懂老师在纸质版桌游中介绍的最复杂的资料。					
16.	In a class like this, I prefer the materials of Paper-Based Board Games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的纸质版本桌游资料；哪怕它是很难学习的。	1	2	3	4	5
17.	I am very interested in the content area of these Paper-Based Board Games. 我对这些纸质版桌游的内容领域很感兴趣。	1	2	3	4	5
18.	If I try hard enough, I will understand the materials in the Paper-Based Board Games. 如果我尝试够了，那么我会理解纸质版桌游当中的资料。	1	2	3	4	5
19.	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	1	2	3	4	5
20.	I’m confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中	1	2	3	4	5

	做得很好。					
21.	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	1	2	3	4	5
22.	The most satisfying thing for me in the Paper-Based Board Games is trying to understand the content as thoroughly as possible. 在纸质版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	1	2	3	4	5
23.	I think the materials of Paper-Based Board Games in this class are useful for me to learn. 我觉得这堂课的纸质版桌游资料对我学习很有用。	1	2	3	4	5
24.	When I have the opportunity in this class, I choose Paper-Based Board Games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的纸质版桌游，即使它们不能保证取得好成绩。	1	2	3	4	5
25.	If I do understand the materials in the Paper-Based Board Games, it is because I	1	2	3	4	5

	didn't try hard enough. 如果我确实了解纸质版桌游的材料，那是因为我还不够努力。					
26.	I like the subject matter of the Paper-Based Board Games. 我喜欢纸质版桌游的主题。	1	2	3	4	5
27.	Understanding the subject matter of the Paper-Based Board Games is very important to me. 了解纸质版桌游的主题对我来说非常重要。	1	2	3	4	5
28.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	1	2	3	4	5
29.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	1	2	3	4	5
30.	I want to do well in this Science classroom because it is important to show my ability to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重	1	2	3	4	5

	要的。					
31.	Considering the difficulty of using Paper-Based Board Games, the teacher, and my skills, I think I will do well in this class. 考虑到纸质版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	1	2	3	4	5

(Revised from Motivated Strategies for Learning Questionnaire (MSLQ) Manual)

Section C: Social Interaction

C 部分：社交互动

The following questions ask about your social interaction for this class. Again, **there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible.** Use the scale below to answer the remaining questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的社交互动。再次提醒，**答案没有对错之分，请尽可能准确地回答有关你如何在本课堂中学习的问题。**同时，也请使用下面的量表来回答问题。如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	Gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	1	2	3	4	5
2.	Gives me a sense of social interaction. 给我一种有社交互动的感觉。	1	2	3	4	5
3.	Makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。	1	2	3	4	5
4.	Makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	1	2	3	4	5
5.	Gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	1	2	3	4	5
6.	Feels like a social experience and support with other group members. 感觉像是与其他组员有着社交体验和支持。	1	2	3	4	5
7.	Gives me a sense of having other group members to share my endeavors with.	1	2	3	4	5

	让我有着一种其他组员与我分享我的努力的感觉。					
8.	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。	1	2	3	4	5
9.	Gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	1	2	3	4	5

(Revised from Gameful Experience Questionnaire).

Thank You

谢谢

APPENDIX P: First Draft of Questionnaire (CBG)

Survey Number: _____

Date: _____ / _____ / 22

Time: _____

Universiti Malaysia Sarawak

Faculty of Cognitive Science and Human Development

A COLLABORATIVE LEARNING OF YEAR 4 SCIENCE SUBJECT USING COMPUTERISED BOARD GAMES

There are 45 questions in this questionnaire.

You will spend around 10 – 15 minutes to answer this questionnaire.

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THIS IS A RESEARCH PROJECT CONDUCTED UNDER FACULTY OF COGNITIVE SCIENCE AND HUMAN DEVELOPMENT UNIVERSITI MALAYSIA SARAWAK TO FULFILL DOCTOR OF PHILOSOPHY RESEARCH

Your answers will be kept confidential.

"Thank you for your cooperation."

你的回答将会被保密。

"谢谢你的合作。"

Section A: Socio-Demographic Characteristics

A 部分：背景问题

Please tick (/) or fill your answer.

请勾选 (/) 或填写您的答案。

1. Age 年龄: _____

2. Class 班级: _____

3. Gender: ( ) Male 男性

   性别 ( ) Female 女性

4. Race: ( ) Malay 马来人 ( ) Chinese 华人

   种族 ( ) Iban 伊班人 ( ) Others 其他: _____

5. Religion: ( ) Muslim ( ) Non-Muslim

   宗教 穆斯林 非穆斯林

Section B: Learning Motivation

B 部分：学习动机

The following questions ask about your motivation for this class. **Remember there are no right or wrong answers, just answer as accurately as possible.** Use the scale below to answer the questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的动机。 **请记住，答案没有对错之分，请尽可能准确地回答**。同时，也请使用下面的量表来回答问题。 如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	1	2	3	4	5
2.	If I study in appropriate ways, I will be able to learn the material of computerized board games in Science. 如果我以适当的方式学习，那么我将能够学习电脑版桌游的科学资料。	1	2	3	4	5
3.	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	1	2	3	4	5
4.	I think I can to use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	1	2	3	4	5
5.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	1	2	3	4	5
6.	I’m certain I can understand the most difficult material presented in the computerized board games for Science	1	2	3	4	5

	subject. 我确信我能理解科学科目电脑版桌游中最难的资料。					
7.	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	1	2	3	4	5
8.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	1	2	3	4	5
9.	It is my own responsibility if I do not learn the material in computerized board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。	1	2	3	4	5
10.	It is important for me to learn Science knowledge in these computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。	1	2	3	4	5
11.	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	1	2	3	4	5

12.	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。	1	2	3	4	5
13.	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	1	2	3	4	5
14.	When I take assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	1	2	3	4	5
15.	I'm confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。	1	2	3	4	5
16.	In a class like this, I prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料；哪怕它是很难学习的。	1	2	3	4	5
17.	I am very interested in the content area of these computerized board games. 我对这些电脑版桌游的内容领域很感兴	1	2	3	4	5

	趣。					
18.	If I try hard enough, I will understand the materials in the computerized board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。	1	2	3	4	5
19.	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	1	2	3	4	5
20.	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	1	2	3	4	5
21.	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	1	2	3	4	5
22.	The most satisfying thing for me in the computerized board games is trying to understand the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	1	2	3	4	5
23.	I think the materials of computerized board games in this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。	1	2	3	4	5
24.	When I have the opportunity in this class, I	1	2	3	4	5

	choose computerized board games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。					
25.	If I do understand the materials in the computerized board games, it is because I didn't try hard enough. 如果我确实了解电脑版卓游的材料，那是因为我还不够努力。	1	2	3	4	5
26.	I like the subject matter of the computerized board games. 我喜欢电脑版桌游的主题。	1	2	3	4	5
27.	Understanding the subject matter of the computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。	1	2	3	4	5
28.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	1	2	3	4	5
29.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	1	2	3	4	5
30.	I want to do well in this Science classroom because it is important to show my ability	1	2	3	4	5

	to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。					
31.	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	1	2	3	4	5

(Revised from Motivated Strategies for Learning Questionnaire (MSLQ) Manual)

Section C: Social Interaction

C 部分：社交互动

The following questions ask about your social interaction for this class. Again, **there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible.** Use the scale below to answer the remaining questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的社交互动。再次提醒，**答案没有对错之分，请尽可能准确地回答有关你如何在本课堂中学习的问题。**同时，也请使用下面的量表来回答问题。如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	Gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	1	2	3	4	5
2.	Gives me a sense of social interaction. 给我一种有社交互动的感觉。	1	2	3	4	5
3.	Makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。	1	2	3	4	5
4.	Makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	1	2	3	4	5
5.	Gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	1	2	3	4	5
6.	Feels like a social experience and support with other group members. 感觉像是与其他组员有着社交体验和支持。	1	2	3	4	5
7.	Gives me a sense of having other group members to share my endeavors with. 让我有着一种其他组员与我分享我的努力的感觉。	1	2	3	4	5
8.	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影	1	2	3	4	5

	响我。					
9.	Gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	1	2	3	4	5

(Revised from Gameful Experience Questionnaire).

Thank You

谢谢

APPENDIX Q: Instruments and Sources for Learning Motivation Part after Implementation of PBBG

NO	SOURCE	VARIABLES / ITEMS	
		Original from source	**Adapted by the researcher**
1	Pintrich et al. (1991)	In a class like this, I prefer course material that really challenges me so I can learn new things.	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。
2		If I study in appropriate ways, then I will be able to learn the material in this course.	If I study in appropriate ways, I will be able to learn the material of Paper-Based Board Games in Science. 如果我以适当的方式学习，那么我将能够学习纸质版桌游的科学资料。
3		When I take a test, I think about how poorly I am doing compared with other students.	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。
4		I think I will be able to use what I learn in this course in other courses.	I think I can use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。
5		I believe I will receive an excellent grade in this class.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。
6		I'm certain I can understand the most difficult material presented in the readings for this course.	I'm certain I can understand the most difficult material presented in the Paper-Based Board Games for Science subjects.

		我确信我能理解科学科目纸质版桌游中最难的资料。
7	Getting a good grade in this class is the most satisfying thing for me right now.	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。
8	When I take a test, I think about items on other parts of the test I can't answer.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。
9	It is my own fault if I don't learn the material in this course.	It is my responsibility if I do not learn the material in Paper-Based Board Games. 如果我不学习纸质版桌游中的资料，那会是我自己的责任。
10	It is important for me to learn the course material in this class.	It is important for me to learn Science knowledge in these Paper-Based Board Games. 在这些纸质版桌游中学习科学知识对我来说很重要。
11	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。
12	I'm confident I can learn the basic concepts taught in this course.	I'm confident I can learn the basic concepts taught in the Paper-Based Board Games. 我相信我可以学习纸质版桌游中教授的基本概念。
13	If I can, I want to get better grades in this class than most of the other students.	If I can, I want to get better grades in the Science classroom than most other pupils.

		如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。
14	When I take test, I think of the consequences of failing.	When I take an assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。
15	I'm confident I can understand the most complex material presented by the instructor in this course.	I'm confident I can understand the most complex material presented by the teacher in the Paper-Based Board Games. 我有信心能听懂老师在纸质版桌游中介绍的最复杂的资料。
16	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	In a class like this, I prefer the materials of Paper-Based Board Games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的纸质版本桌游资料；哪怕它是很难学习的。
17	I am very interested in the content area of this course.	I am very interested in the content area of these Paper-Based Board Games. 我对这些纸质版桌游的内容领域很感兴趣。
18	If I try hard enough, then I will understand the course material.	If I try hard enough, I will understand the materials in the Paper-Based Board Games. 如果我尝试够了，那么我会理解纸质版桌游当中的资料。
19	I have an uneasy, upset feeling when I take an exam.	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。
20	I'm confident I can do an excellent job on the assignments and tests in this course.	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。

21	I expect to do well in this class.	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。
22	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	The most satisfying thing for me in Paper-Based Board Games is understanding the content as thoroughly as possible. 在纸质版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。
23	I think the course material in this class is useful for me to learn.	I think the materials of Paper-Based Board Games in this class are useful for me to learn. 我觉得这堂课的纸质版桌游资料对我学习很有用。
24	When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.	When I have the opportunity in this class, I choose Paper-Based Board Games that I can learn from even if they don’t guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的纸质版桌游，即使它们不能保证取得好成绩。
25	If I don't understand the course material, it is because I didn’t try hard enough.	If I do understand the materials in the Paper-Based Board Games, it is because I didn’t try hard enough. 如果我确实了解纸质版桌游的材料，那是因为我还不够努力。
26	I like the subject matter of this course.	I like the subject matter of Paper-Based Board Games. 我喜欢纸质版桌游的主题。
27	Understanding the subject matter of this course is very important to me.	Understanding the subject matter of Paper-Based Board Games is very important to me. 了解纸质版桌游的主题对我来说非常重要。

28	I feel my heart beating fast when I take an exam.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。
29	I'm certain I can master the skills being taught in this class.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。
30	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	I want to do well in this Science classroom because it is important to show my ability to my family, friends, and others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。
31	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	Considering the difficulty of using Paper-Based Board Games, the teacher, and my skills, I think I will do well in this class. 考虑到纸质版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。

APPENDIX R: Instruments and Sources for Learning Motivation Part after Implementation of CBG

NO	SOURCE	VARIABLES / ITEMS	
		Original from source	**Adapted by the researcher**
1	Pintrich et al. (1991).	In a class like this, I prefer course material that really challenges me so I can learn new things.	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。
2		If I study in appropriate ways, then I will be able to learn the material in this course.	If I study appropriately, I can learn the material of computerized board games in Science. 如果我以适当的方式学习，那么我将能够学习电脑版桌游的科学资料。
3		When I take a test, I think about how poorly I am doing compared with other students.	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。
4		I think I will be able to use what I learn in this course in other courses.	I think I can to use what I learn in Science in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。
5		I believe I will receive an excellent grade in this class.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。

6	I'm certain I can understand the most difficult material presented in the readings for this course.	I'm certain I can understand the most difficult material presented in the computerized board games for Science subjects. 我确信我能理解科学科目电脑版桌游中最难的资料。
7	Getting a good grade in this class is the most satisfying thing for me right now.	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。
8	When I take a test, I think about items on other parts of the test I can't answer.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。
9	It is my own fault if I don't learn the material in this course.	It is my own responsibility if I do not learn the material in computerized board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。
10	It is important for me to learn the course material in this class.	It is important for me to learn Science knowledge in these computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。
11	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.	The most important thing for me right now is improving my performance, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的

		是取得好成绩。
12	I'm confident I can learn the basic concepts taught in this course.	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。
13	If I can, I want to get better grades in this class than most of the other students.	If I can, I want to get better grades in the Science classroom than most other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。
14	When I take test, I think of the consequences of failing.	When I take a test, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。
15	I'm confident I can understand the most complex material presented by the instructor in this course.	I'm confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。
16	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	In a class like this, I prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料； 哪怕它是很难学习的。
17	I am very interested in the content area of this course.	I am very interested in the content area of these computerized board games. 我对这些电脑版桌游的内容

		领域很感兴趣。
18	If I try hard enough, then I will understand the course material.	If I try hard enough, I will understand the materials in the computerized board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。
19	I have an uneasy, upset feeling when I take an exam.	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。
20	I'm confident I can do an excellent job on the assignments and tests in this course.	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。
21	I expect to do well in this class.	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。
22	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	The most satisfying thing for me in computerized board games is understanding the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。
23	I think the course material in this class is useful for me to learn.	I think the materials of computerized board games in this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。
24	When I have the opportunity in this class, I choose course assignments that I can learn	When I have the opportunity in this class, I choose computerized board games

	from even if they don't guarantee a good grade.	that I can learn from even if they do not guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。
25	If I don't understand the course material, it is because I didn’t try hard enough.	If I do understand the materials in the computerized board games, it is because I didn't try hard enough. 如果我确实了解电脑版桌游的材料，那是因为我还不够努力。
26	I like the subject matter of this course.	I like the subject matter of the computerized board games. 我喜欢电脑版桌游的主题。
27	Understanding the subject matter of this course is very important to me.	Understanding the subject matter of computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。
28	I feel my heart beating fast when I take an exam.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。
29	I'm certain I can master the skills being taught in this class.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。
30	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	I want to do well in this Science classroom because it is important to show my ability to my family, friends, and others. 我想在这课堂上取得好成

		绩，因为向家人、朋友或其他人展示我的能力是很重要的。
31	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。

APPENDIX S: Instruments and Sources for Social Interaction Part after Implementation of PBBG and CBG

NO	SOURCE	VARIABLES / ITEMS	
		Original from source	**Adapted by the researcher**
1	Högberg et al. (2019)	Gives me the feeling that I'm not on my own	Gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。
2		Gives me a sense of social support	Gives me a sense of social interaction. 给我一种有社交互动的感觉。
3		Makes me feel like I have someone to work with	Makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。
4		Makes me feel like I am socially involved	Makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。
5		Gives me a feeling of being connected to others	Gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。
6		Feels like a social experience	Feels like a social experience and support from other group members. 感觉像是与其他组员有着社交体验和支持。
7		Gives me a sense of having someone to share my endeavors with	Gives me a sense of having other group members to share my endeavours with. 让我有着一种其他组员与我分享我的努力的感觉。

8	Influences me through its social aspects	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。
9	Gives me a sense of being noticed for what I have achieved	Gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。

APPENDIX T

Survey Number: _____

Date: _____ / _____ / 22

Time: _____

Universiti Malaysia Sarawak

Faculty of Cognitive Science and Human Development

A COLLABORATIVE LEARNING OF YEAR 4 SCIENCE SUBJECT USING COMPUTERISED BOARD GAMES

There are 45 questions in this questionnaire.

You will spend around 10 – 15 minutes to answer this questionnaire.

本问卷共有 45 个问题。

THIS IS A RESEARCH PROJECT CONDUCTED UNDER THE FACULTY OF COGNITIVE SCIENCE AND HUMAN DEVELOPMENT UNIVERSITI MALAYSIA SARAWAK TO FULFILL DOCTOR OF PHILOSOPHY RESEARCH

Your answers will be kept confidential.

"Thank you for your cooperation."

你的回答将会被保密。

"谢谢你的合作。"

Section A: Socio-Demographic Characteristics

A 部分：背景问题

Please tick (/) or fill your answer.

请勾选 (/) 或填写您的答案。

1. Age 年龄: _____

2. Class 班级: _____

3. Gender: ( ) Male 男性

   性别 ( ) Female 女性

4. Race: ( ) Malay 马来人 ( ) Chinese 华人

   种族 ( ) Iban 伊班人 ( ) Others 其他: _____

5. Religion: ( ) Muslim ( ) Non-Muslim

   宗教 穆斯林 非穆斯林

Section B: Learning Motivation

B 部分：学习动机

The following questions ask about your motivation for this class. **Remember, there are no right or wrong answers, just answer as accurately as possible.** Use the scale below to answer the questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的动机。 **请记住，答案没有对错之分，请尽可能准确地回答**。同时，也请使用下面的量表来回答问题。 如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	In a science classroom like this, I prefer	1	2	3	4	5

	science knowledge can challenge me so that I am able to learn new things. 在这样的科学课堂上，我喜欢那些可以真正挑战我的科学只是，以便我能够学习到新的事物。					
2.	If I am given more chances, I will be able to learn the materials of Paper-Based Board Games in science. 如果我有着更多的机会，那么我将能够学习纸质版桌游的科学资料。	1	2	3	4	5
3.	I think I can to use what I learn in science in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	1	2	3	4	5
4.	I'm certain I can understand the most difficult material presented in the Paper-Based Board Games for science subject. 我确信我能理解科学科目纸质版桌游中最难的资料。	1	2	3	4	5
5.	I'm confident I can learn the basic concepts taught in the Paper-Based Board Games. 我相信我可以学习纸质版桌游中教授的基本概念。	1	2	3	4	5

6.	I'm confident I can understand the most complex material presented by the teacher in the Paper-Based Board Games. 我有信心能听懂老师在纸质版桌游中介绍的最复杂的资料。	1	2	3	4	5
7.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	1	2	3	4	5
8.	Considering the difficulty of using Paper-Based Board Games, the teacher, and my skills, I think I will do well in this class. 考虑到纸质版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	1	2	3	4	5
9.	When I take a test, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	1	2	3	4	5
10.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	1	2	3	4	5
11.	Getting a good grade in science is the most satisfying thing for me.	1	2	3	4	5

	在科学课取得好成绩是我最满意的事情。					
12.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	1	2	3	4	5
13.	The most important thing for me right now is improving my performance level, so my main concern in the science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	1	2	3	4	5
14.	If I can, I want to get better grades in the science classroom than most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	1	2	3	4	5
15.	When I take test, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	1	2	3	4	5
16.	I do not feel uneasy or upset feeling when	1	2	3	4	5

	I take an assessment. 当我进行评估时，我没有不安和失望的感觉。					
17.	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	1	2	3	4	5
18.	I expect to do well in this science classroom. 我希望在这科学课堂上取得好成绩。	1	2	3	4	5
19.	When I have the opportunity in this class, I choose Paper-Based Board Games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的纸质版桌游，即使它们不能保证取得好成绩。	1	2	3	4	5
20.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	1	2	3	4	5
21.	I want to do well in this science classroom because it is important to show my ability to my family, friends, or others.	1	2	3	4	5

	我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。					
22.	It is my own responsibility if I do not learn the material in Paper-Based Board Games. 如果我不学习纸质版桌游中的资料，那会是我自己的责任。	1	2	3	4	5
23.	It is important for me to learn science knowledge in these Paper-Based Board Games. 在这些纸质版桌游中学习科学知识对我来说很重要。	1	2	3	4	5
24.	In a class like this, I prefer the materials of Paper-Based Board Games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的纸质版本桌游资料；哪怕它是很难学习的。	1	2	3	4	5
25.	I am very interested in the content area of these Paper-Based Board Games. 我对这些纸质版桌游的内容领域很感兴趣。	1	2	3	4	5
26.	If I try hard enough, I will understand the materials in the Paper-Based Board	1	2	3	4	5

	Games. 如果我尝试够了，那么我会理解纸质版桌游当中的资料。					
27.	The most satisfying thing for me in the Paper-Based Board Games is trying to understand the content as thoroughly as possible. 在纸质版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	1	2	3	4	5
28.	I think the materials for Paper-Based Board Games in this class are useful for me to learn. 我觉得这堂课的纸质版桌游资料对我学习很有用。	1	2	3	4	5
29.	If I do understand the materials in the Paper-Based Board Games, it is because I didn't try hard enough. 如果我确实了解纸质版桌游的材料，那是因为我还不够努力。	1	2	3	4	5
30.	I like the subject matter of the Paper-Based Board Games. 我喜欢纸质版桌游的主题。	1	2	3	4	5
31.	Understanding the subject matter of the Paper-Based Board Games is very	1	2	3	4	5

	important to me. 了解纸质版桌游的主题对我来说非常重要。					

(Revised from Motivated Strategies for Learning Questionnaire (MSLQ) Manual)

Section C: Social Interaction

C 部分：社交互动

The following questions ask about your social interaction for this class. Again, **there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible.** Use the scale below to answer the remaining questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

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1 – Strongly Disagree

非常不同意

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3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

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No. 编号	Items 陈述	Scales 评分				
1.	It gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	1	2	3	4	5
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3.	It makes me feel that I work together with others in achieving goals. 让我有着与他人一块合作来达到目的的感觉。	1	2	3	4	5
4.	It makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	1	2	3	4	5
5.	It gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	1	2	3	4	5
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9.	It gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	1	2	3	4	5

(Revised from Gameful Experience Questionnaire).

Thank You

谢谢

APPENDIX U

Survey Number: _____

Date: _____ / _____ / 22

Time: _____

Universiti Malaysia Sarawak

Faculty of Cognitive Science and Human Development

A COLLABORATIVE LEARNING OF YEAR 4 SCIENCE SUBJECT USING COMPUTERISED BOARD GAMES

There are 45 questions in this questionnaire.

You will spend around 10 – 15 minutes to answer this questionnaire.

本问卷共有 45 个问题。

THIS IS A RESEARCH PROJECT CONDUCTED UNDER THE FACULTY OF COGNITIVE SCIENCE AND HUMAN DEVELOPMENT UNIVERSITI MALAYSIA SARAWAK TO FULFILL DOCTOR OF PHILOSOPHY RESEARCH

Your answers will be kept confidential.

"Thank you for your cooperation."

你的回答将会被保密。

"谢谢你的合作。"

Section A: Socio-Demographic Characteristics

A 部分：背景问题

Please tick (/) or fill your answer.

请勾选 (/) 或填写您的答案。

1. Age 年龄: _____

2. Class 班级: _____

3. Gender: ( ) Male 男性

   性别 ( ) Female 女性

4. Race: ( ) Malay 马来人 ( ) Chinese 华人

   种族 ( ) Iban 伊班人 ( ) Others 其他: _____

5. Religion: ( ) Muslim ( ) Non-Muslim

   宗教 穆斯林 非穆斯林

Section B: Learning Motivation

B 部分：学习动机

The following questions ask about your motivation for this class. **Remember, there are no right or wrong answers, just answer as accurately as possible.** Use the scale below to answer the questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

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3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	In a science classroom like this, I prefer	1	2	3	4	5

	science knowledge can challenge me so that I am able to learn new things. 在这样的科学课堂上，我喜欢那些可以真正挑战我的科学只是，以便我能够学习到新的事物。					
2.	If I am given more chances, I will be able to learn the materials of computerised board games in science. 如果我有着更多的机会，那么我将能够学习电脑版桌游的科学资料。	1	2	3	4	5
3.	I think I can to use what I learn in science in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	1	2	3	4	5
4.	I'm certain I can understand the most difficult material presented in the computerised board games for science subject. 我确信我能理解科学科目电脑版桌游中最难的资料。	1	2	3	4	5
5.	I'm confident I can learn the basic concepts taught in the computerised board games. 我相信我可以学习电脑版桌游中教授的	1	2	3	4	5

	基本概念。					
6.	I'm confident I can understand the most complex material presented by the teacher in the computerised board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。	1	2	3	4	5
7.	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	1	2	3	4	5
8.	Considering the difficulty of using computerised board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	1	2	3	4	5
9.	When I take a test, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	1	2	3	4	5
10.	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	1	2	3	4	5

11.	Getting a good grade in science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	1	2	3	4	5
12.	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	1	2	3	4	5
13.	The most important thing for me right now is improving my performance level, so my main concern in the science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	1	2	3	4	5
14.	If I can, I want to get better grades in the science classroom than most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	1	2	3	4	5
15.	When I take test, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后	1	2	3	4	5

	果。					
16.	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	1	2	3	4	5
17.	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	1	2	3	4	5
18.	I expect to do well in this science classroom. 我希望在这科学课堂上取得好成绩。	1	2	3	4	5
19.	When I have the opportunity in this class, I choose computerised board games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。	1	2	3	4	5
20.	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	1	2	3	4	5
21.	I want to do well in this science classroom	1	2	3	4	5

	because it is important to show my ability to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。					
22.	It is my own responsibility if I do not learn the material in computerised board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。	1	2	3	4	5
23.	It is important for me to learn science knowledge in these computerised board games. 在这些电脑版桌游中学习科学知识对我来说很重要。	1	2	3	4	5
24.	In a class like this, I prefer the materials of computerised board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料；哪怕它是很难学习的。	1	2	3	4	5
25.	I am very interested in the content area of these computerised board games. 我对这些电脑版桌游的内容领域很感兴趣。	1	2	3	4	5

26.	If I try hard enough, I will understand the materials in the computerised board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。	1	2	3	4	5
27.	The most satisfying thing for me in the computerised board games is trying to understand the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	1	2	3	4	5
28.	I think the materials for computerised board games in this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。	1	2	3	4	5
29.	If I do understand the materials in the computerised board games, it is because I didn't try hard enough. 如果我确实了解电脑版桌游的材料，那是因为我还不够努力。	1	2	3	4	5
30.	I like the subject matter of the computerised board games. 我喜欢电脑版桌游的主题。	1	2	3	4	5

31.	Understanding the subject matter of the computerised board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。	1	2	3	4	5

(Revised from Motivated Strategies for Learning Questionnaire (MSLQ) Manual)

Section C: Social Interaction

C 部分：社交互动

The following questions ask about your social interaction for this class. Again, **there are no right or wrong answers. Answer the questions about how you study in this class as accurately as possible.** Use the scale below to answer the remaining questions. If you strongly agree with the statement, circle 5; if you strongly disagree with the statement, circle 1. If the statement is more or less agree or disagree, find the number between 1 and 5 that best describes it.

以下的问题是询问你参加本课堂的社交互动。再次提醒，**答案没有对错之分，请尽可能准确地回答有关你如何在本课堂中学习的问题。**同时，也请使用下面的量表来回答问题。如果你非常同意该陈述，请圈出 5； 如果你非常不同意该陈述，请圈出 1。如果你对该陈述有着或多或少同意，又或者是不同意的看法，请找出最能描述该陈述 1 到 5 之间的数字。

1 – Strongly Disagree

非常不同意

2 – Disagree

不同意

3 – Undecided

未定

4 – Agree

同意

5 – Strongly Agree

非常同意

No. 编号	Items 陈述	Scales 评分				
1.	It gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	1	2	3	4	5
2.	It gives me a sense of social interaction. 给我一种有社交互动的感觉。	1	2	3	4	5
3.	It makes me feel that I work together with others in achieving goals. 让我有着与他人一块合作来达到目的的感觉。	1	2	3	4	5
4.	It makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	1	2	3	4	5
5.	It gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	1	2	3	4	5
6.	Feels like a social experience and support with other group members. 感觉像是与其他组员有着社交体验和支持。	1	2	3	4	5

7.	It gives me a sense of having other group members to share my endeavors with. 让我有着一种其他组员与我分享我的努力的感觉。	1	2	3	4	5
8.	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。	1	2	3	4	5
9.	It gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	1	2	3	4	5

(Revised from Gameful Experience Questionnaire).

Thank You

谢谢

APPENDIX V

Instruments and Sources for Learning Motivation Part in implementing PBBG after Discussion with Two experienced Science Teachers

NO	SOURCE	VARIABLES / ITEMS	
		Adapted by the researcher	**After Discussion**
1	Pintrich et al. (1991).	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	In a Science classroom like this, I prefer Science knowledge can challenge me so that I can learn new things. 在这样的科学课堂上，我喜欢那些可以真正挑战我的科学只是，以便我能够学习到新的事物。
2		If I study in appropriate ways, I will be able to learn the material of Paper-Based Board Games in Science. 如果我以适当的方式学习，那么我将能够学习纸质版桌游的科学资料。	If I am given more chances, I will be able to learn the materials of Paper-Based Board Games in Science. 如果我有着更多的机会，那么我将能够学习纸质版桌游的科学资料。
3		When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	I think I can to use what I learn in Science in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。
4		I think I can to use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	I'm certain I can understand the most difficult material presented in Paper-Based Board Games for Science subjects. 我确信我能理解科学科目纸质版桌游中最难的资料。
5		I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	I'm confident I can learn the basic concepts taught in the Paper-Based Board Games. 我相信我可以学习纸质版桌游中教授的基本概念。
6		I'm certain I can understand the	I'm confident I can understand

	most difficult material presented in the Paper-Based Board Games for Science subject. 我确信我能理解科学科目纸质版桌游中最难的资料。	the most complex material presented by the teacher in the Paper-Based Board Games. 我有信心能听懂老师在纸质版桌游中介绍的最复杂的资料。
7	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。
8	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	Considering the difficulty of using Paper-Based Board Games, the teacher, and my skills, I think I will do well in this class. 考虑到纸质版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。
9	It is my own responsibility if I do not learn the material in Paper-Based Board Games. 如果我不学习纸质版桌游中的资料，那会是我自己的责任。	When I take a test, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。
10	It is important for me to learn Science knowledge in these Paper-Based Board Games. 在这些纸质版桌游中学习科学知识对我来说很重要。	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。
11	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。
12	I'm confident I can learn the basic concepts taught in the Paper-	When I take an assessment, I do not think about items on

	Based Board Games. 我相信我可以学习纸质版桌游中教授的基本概念。	other parts of the assessment I cannot answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。
13	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	The most important thing for me right now is improving my performance, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。
14	When I take assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	If I can, I want to get better grades in the Science classroom than most other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。
15	I'm confident I can understand the most complex material presented by the teacher in the Paper-Based Board Games. 我有信心能听懂老师在纸质版桌游中介绍的最复杂的资料。	When I take the test, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。
16	In a class like this, I prefer the materials of Paper-Based Board Games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的纸质版本桌游资料；哪怕它是很难学习的。	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。
17	I am very interested in the content area of these Paper-Based Board Games. 我对这些纸质版桌游的内容领域很感兴趣。	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。
18	If I try hard enough, I will	I expect to do well in this

	understand the materials in the Paper-Based Board Games. 如果我尝试够了，那么我会理解纸质版桌游当中的资料。	Science classroom. 我希望在这科学课堂上取得好成绩。
19	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	When I have the opportunity in this class, I choose Paper-Based Board Games that I can learn from even if they do not guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的纸质版桌游，即使它们不能保证取得好成绩。
20	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。
21	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	I want to do well in this Science classroom because it is important to show my ability to my family, friends, and others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。
22	The most satisfying thing for me in the Paper-Based Board Games is trying to understand the content as thoroughly as possible. 在纸质版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	It is my responsibility if I do not learn the material in Paper-Based Board Games. 如果我不学习纸质版桌游中的资料，那会是我自己的责任。
23	I think the materials of Paper-Based Board Games in this class are useful for me to learn. 我觉得这堂课的纸质版桌游资料对我学习很有用。	I need learn Science knowledge in these Paper-Based Board Games. 在这些纸质版桌游中学习科学知识对我来说很重要。
24	When I have the opportunity in this class, I choose Paper-Based	In a class like this, I prefer the materials of Paper-Based

	Board Games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的纸质版桌游，即使它们不能保证取得好成绩。	Board Games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的纸质版本桌游资料； 哪怕它是很难学习的。
25	If I do understand the materials in the Paper-Based Board Games, it is because I didn't try hard enough. 如果我确实了解纸质版桌游的材料，那是因为我还不够努力。	I am very interested in the content area of these Paper-Based Board Games. 我对这些纸质版桌游的内容领域很感兴趣。
26	I like the subject matter of the Paper-Based Board Games. 我喜欢纸质版桌游的主题。	If I try hard enough, I will understand the materials in the Paper-Based Board Games. 如果我尝试够了，那么我会理解纸质版桌游当中的资料。
27	Understanding the subject matter of the Paper-Based Board Games is very important to me. 了解纸质版桌游的主题对我来说非常重要。	The most satisfying thing for me in Paper-Based Board Games is understanding the content as thoroughly as possible. 在纸质版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。
28	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	I think the materials for Paper-Based Board Games in this class are useful for learning. 我觉得这堂课的纸质版桌游资料对我学习很有用。
29	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	If I do understand the materials in the Paper-Based Board Games, it is because I didn't try hard enough. 如果我确实了解纸质版桌游的材料，那是因为我还不够努力。

30	I want to do well in this Science classroom because it is important to show my ability to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。	I like the subject matter of Paper-Based Board Games. 我喜欢纸质版桌游的主题。
31	Considering the difficulty of using Paper-Based Board Games, the teacher, and my skills, I think I will do well in this class. 考虑到纸质版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	Understanding the subject matter of Paper-Based Board Games is very important to me. 了解纸质版桌游的主题对我来说非常重要。

APPENDIX W

Instruments and Sources for Learning Motivation Part in implementing CBG after Discussion with Two Experienced Science Teachers

NO	SOURCE	VARIABLES / ITEMS	
		Adapted by the researcher	**After Discussion**
1	Pintrich et al. (1991).	In a Science classroom like this, I prefer Science material that challenges me so I can learn new things. 在这样的科学课堂上，我更喜欢真正挑战我的科学材料，这样我就可以学习新事物。	In a Science classroom like this, I prefer Science knowledge can challenge me so that I can learn new things. 在这样的科学课堂上，我喜欢那些可以真正挑战我的科学只是，以便我能够学习到新的事物。
2		If I study in appropriate ways, I will be able to learn the material of computerized board games in Science. 如果我以适当的方式学习，那么我将能够学习电脑版桌游的科学资料。	If given more chances, I will be able to learn the materials of computerized board games in Science. 如果我有着更多的机会，那么我将能够学习电脑版桌游的科学资料。
3		When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。	I think I can use what I learn in Science subject in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。
4		I think I can to use what I learn in Science in other subjects. 我想我能够将我在科学科目中学到的知识运用到其他科目中。	I'm certain I can understand the most difficult material presented in the computerized board games for Science subjects. 我确信我能理解科学科目电脑版桌游中最难的资料。
5		I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。

6	I'm certain I can understand the most difficult material presented in the computerized board games for Science subjects. 我确信我能理解科学科目电脑版桌游中最难的资料。	I'm confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。
7	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。
8	When I take an assessment, I do not think about items on other parts of the assessment I can't answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。
9	It is my own responsibility if I do not learn the material in computerized board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。	When I take an assessment, I think about how well I am doing compared with other pupils. 当我参加评估时，我会考虑到与其他学生的表现来做出对比。
10	It is important for me to learn Science knowledge in these computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。	I believe I will receive an excellent grade in the subject assessment. 我相信我会在科目考试中获得优异的成绩。
11	The most important thing for me right now is improving my performance level, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得	Getting a good grade in Science is the most satisfying thing for me. 在科学课取得好成绩是我最满意的事情。

	好成绩。	
12	I'm confident I can learn the basic concepts taught in the computerized board games. 我相信我可以学习电脑版桌游中教授的基本概念。	When I take an assessment, I do not think about items on other parts of the assessment I cannot answer. 当我参加测验时，我不会考虑其他部分我无法回答的问题。
13	If I can, I want to get better grades in the Science classroom than most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。	The most important thing for me right now is improving my performance, so my main concern in the Science classroom is getting a good grade. 现在对我来说最重要的是提高我的整体平均成绩，所以我在科学课堂上主要关心的是取得好成绩。
14	When I take a test, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。	If I can, I want to get better grades in Science classroom that most of the other pupils. 如果可以的话，我想在科学课堂上取得比其他大多数学生更好的成绩。
15	I'm confident I can understand the most complex material presented by the teacher in the computerized board games. 我有信心能听懂老师在电脑版桌游中介绍的最复杂的资料。	When I take the assessment, I do not think of the consequences of failing. 当我参加评估时，我不考虑失败的后果。
16	In a class like this, I prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料；哪怕它是很难学习的。	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。
17	I am very interested in the content area of these computerized board games.	I’m confident I can do an excellent job on formative and summative assessments.

	我对这些电脑版桌游的内容领域很感兴趣。	我相信我可以在形成性和总结性评估中做得很好。
18	If I try hard enough, I will understand the materials in the computerized board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。
19	I do not feel uneasy or upset feeling when I take an assessment. 当我进行评估时，我没有不安和失望的感觉。	When I have the opportunity in this class, I choose computerized board games that I can learn from even if they do not guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。
20	I'm confident I can do an excellent job on formative and summative assessments. 我相信我可以在形成性和总结性评估中做得很好。	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。
21	I expect to do well in this Science classroom. 我希望在这科学课堂上取得好成绩。	I want to do well in this Science classroom because it is important to show my ability to my family, friends, and others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。
22	The most satisfying thing for me in the computerized board games is trying to understand the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。	It is my responsibility if I do not learn the material in computerized board games. 如果我不学习电脑版桌游中的资料，那会是我自己的责任。
23	I think the materials of computerized board games in	I need to learn Science knowledge in these

	this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。	computerized board games. 在这些电脑版桌游中学习科学知识对我来说很重要。
24	When I have the opportunity in this class, I choose computerized board games that I can learn from even if they don't guarantee a good grade. 当我有机会上这课堂时，我会选择可以学习的电脑版桌游，即使它们不能保证取得好成绩。	In a class like this, I prefer the materials of computerized board games that arouse my curiosity, even if it is difficult to learn. 在这样的课堂上，我更喜欢能引起我好奇心的电脑版本桌游资料； 哪怕它是很难学习的。
25	If I do understand the materials in the computerized board games, it is because I didn't try hard enough. 如果我确实了解电脑版桌游的材料，那是因为我还不够努力。	I am very interested in the content area of these computerized board games. 我对这些电脑版桌游的内容领域很感兴趣。
26	I like the subject matter of the computerized board games. 我喜欢电脑版桌游的主题。	If I try hard enough, I will understand the materials in the computerized board games. 如果我尝试够了，那么我会理解电脑版桌游当中的资料。
27	Understanding the subject matter of the computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。	The most satisfying thing for me in computerized board games is understanding the content as thoroughly as possible. 在电脑版桌游中，对我来说最令人满意的事情是尽可能彻底地理解内容。
28	I feel my heart beating fast when I take a quiz. 当我进行小考时，我感到我的心跳加速。	I think the materials of computerized board games in this class are useful for me to learn. 我觉得这堂课的电脑版桌游资料对我学习很有用。

29	I'm certain I can master the scientific knowledge being taught in this class. 我确信我可以掌握这课堂所教授的技能。	If I do understand the materials in the computerized board games, it is because I did not try hard enough. 如果我确实了解电脑版卓游的材料，那是因为我还不够努力。
30	I want to do well in this Science classroom because it is important to show my ability to my family, friends, or others. 我想在这课堂上取得好成绩，因为向家人、朋友或其他人展示我的能力是很重要的。	I like the subject matter of computerized board games. 我喜欢电脑版桌游的主题。
31	Considering the difficulty of using computerized board games, the teacher, and my skills, I think I will do well in this class. 考虑到电脑版桌游的难度、老师和我的技能，我想我会在这课堂上做得很好。	Understanding the subject matter of computerized board games is very important to me. 了解电脑版桌游的主题对我来说非常重要。

APPENDIX X

Instruments and Sources for Social Interaction Part after Discussion with Two experienced Science Teachers

NO	SOURCE	VARIABLES / ITEMS	
		Adapted by Researcher	**After Discussion**
1	Högberg et al. (2019)	Gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。	It gives me the feeling that I'm not learning by myself. 给我有一种不是在自学的感觉。
2		Gives me a sense of social interaction. 给我一种有社交互动的感觉。	It gives me a sense of social interaction. 给我一种有社交互动的感觉。
3		Makes me feel that I collaborate with others. 让我有着我与他人合作的感觉。	It makes me feel that I work together with others to achieve goals. 让我有着与他人一块合作来达到目的的感觉。
4		Makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。	It makes me feel that I am socially involved with other group members. 让我有一种与其他组员进行社交活动的感觉。
5		Gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。	It gives me a feeling of being collaborative with other group members. 给我一种与其他组员合作的感觉。
6		Feels like a social experience and support with other group members. 感觉像是与其他组员有着社交体验和支持。	Feels like a social experience and support from other group members. 感觉像是与其他组员有着社交体验和支持。
7		Gives me a sense of having other group members to share my endeavors with.	It gives me a sense of having other group members to share my endeavors with.

	让我有着一种其他组员与我分享我的努力的感觉。	让我有着一种其他组员与我分享我的努力的感觉。
8	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。	Influences me through its social and collaborative aspects with other group members. 通过与其他组员的社交和协作方面来影响我。
9	Gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。	It gives me a sense of being noticed for what I have obtained with other group members. 让我有一种被其他组员关注的感觉。

APPENDIX Y

Classroom Observation Protocol

Instructions to the observer:

Please fill in all of the spaces below. Write your observational field notes the same day you conduct your observation. Also, discuss with your co-observer the observation. Refer back to the recording from the screen recorder for clearer observation as well. If possible, conduct an interview as soon as the observation ends for clarification or seek permission to interview the participants (Year 4 pupils) later, preferably within one week of the observation date.

PART 1: BACKGROUND INFORMATION

Observer (s):

i. _____

ii. _____

iii. _____

Observation date: _____ Observation Start Time: _____

Length of the Observation: _____ minutes Observation End Time: _____

Venue: _____ Subject: _____

Teacher's Name: _____ Topic: _____

Number of Pupils: _____

PART 2: OBSERVATION NOTES

In this section, please take detailed notes as you observe classroom activities.

The following questions are guidelines for what you will document during the classroom observation. Your descriptions of the classroom activities should include answers to the questions in 2.1 – 2.5. For each topic/question, please note what you observe in the left-hand column and use the right-hand column to note what you think.

2.1 Structure of the Lesson

Describe the structure of the lesson that you observe. What is happening in the classroom at the beginning, middle and end? What are the teacher and the pupils doing?

Observational Notes	Reflective Notes

2.2 Interactions between the Teacher and Students

How do the teacher and pupils interact? Give examples of the type of questions the teacher asks pupils and how pupils respond, as well as the questions the pupils ask the teacher and the teacher's response. In addition to questions, please note the other ways the teacher and the pupils interact.

Observational Notes	Reflective Notes

2.3 Interaction among Pupils

Do pupils have an opportunity to interact with one another? If so, how do they interact? For example, do they work on a task together? Do they provide feedback to one another?

Observational Notes	Reflective Notes

2.4 Use of the Technology/Device/Resources

Are the technology/device/resources used as part of the activity? If so, how and for what purpose? Is the teacher or pupils experiencing difficulties using the technology/device/resources? Are they able to troubleshoot? What other resources/devices does the teacher use? (e.g. chart paper, whiteboard, visual aids, computers, lab equipment etc.)

Observational Notes	Reflective Notes

2.5 Other Observations

What else do the teacher and pupils do?

Observational Notes	Reflective Notes

Revised from Classroom Observation Protocol (Swaran Singh et al., 2017)

Thank You

APPENDIX Z

Classroom Observation Protocol

Instructions to the observer:

Please fill in all of the spaces below. Write your observational field notes the same day you conduct your observation. Also, discuss with your co-observer the observation. Refer back to the recording from the screen recorder for clearer observation as well. If possible, conduct an interview as soon as the observation ends for clarification or seek permission to interview the participants (Year 4 pupils) later, preferably within one week of the observation date.

PART 1: BACKGROUND INFORMATION

Observer (s):

i. _____

ii. _____

iii. _____

Observation date: _____ Observation Start Time: _____

Length of the Observation: _____ minutes Observation End Time: _____

Venue: _____ Subject: _____

Teacher's Name: _____ Topic: _____

Number of Pupils: _____

PART 2: OBSERVATION NOTES

In this section, please take detailed notes as you observe classroom activities.

The following questions are guidelines for what you will document during the classroom observation. Your descriptions of the classroom activities should include answers to the questions in 2.1 – 2.5. For each topic/question, please note what you observe in the left-hand column and use the right-hand column to note what you think.

2.1 Structure of the Lesson

Describe the structure of the lesson that you observe. What is happening in the classroom at the beginning, middle and end? What are the teacher and the pupils doing?

Observational Notes	Reflective Notes

2.2 Interactions between the Teacher and Students

How do the teacher and pupils interact? Give examples of the type of questions the teacher asks pupils and how pupils respond, as well as the questions the pupils ask the teacher and the teacher's response. In addition to questions, please note the other ways the teacher and the pupils interact.

Observational Notes	Reflective Notes

2.3 Interaction among Pupils

Do pupils have an opportunity to interact with one another? If so, how do they interact? For example, do they work on a task together? Do they provide feedback to one another?

Observational Notes	Reflective Notes

2.4 Use of the Technology/Device/Resources

Are the technology/device/resources used as part of the activity? If so, how and for what purpose? Is the teacher or pupils experiencing difficulties using the technology/device/resources? Are they able to troubleshoot? What other resources/devices does the teacher use? (e.g. chart paper, whiteboard, visual aids, computers, lab equipment etc.)

Observational Notes	Reflective Notes

2.5 Other Observations

What else do the teacher and pupils do?

Observational Notes	Reflective Notes

Revised from Classroom Observation Protocol (Swaran Singh et al., 2017)

Thank You

APPENDIX AA

Interview Protocol

访谈协议

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你被邀请参与这一项研究，其目的是为了研究运用纸质版桌游（PBBG）来识别社交互动的特征以及评估学习科学的动机程度。为了确保你的保密性和资源性，你可以在开始之前先阅读这一份访谈协议中所提供的问题。除此之外，访问者也会特别注意着装和外表，同时也不经意间地向受访者展示身为研究者的成熟和专业。为了确保在访谈过程中所有的反馈得以获得，我将会使用录音机来进行录音的工作，并且记录受访者所透露的想法。整个访谈的时间将不会超过 20 分钟。据你所知，本次的访谈结束后，其数据将会根据研究目的来逐字转录、进行编码以及主题化。

Time of interview 访谈时间: _____

Date 日期: _____

Place 地点: _____

Interviewer 访问者: _____

Interviewee 受访者: _____

Interview Questions 访谈问题:

1. Tell me about yourself.
   介绍一下你自己。

   _____

2. Do you know how to use board games and learn knowledge?
   你知道如何使用桌游和学习知识吗?

   _____

3. Do you enjoy learning Science? Why?
   你喜欢学习科学吗? 为什么?

   _____

4. What do you think about Paper-Based Board Games?
   你对纸质版桌游有什么看法?

   _____

5. Do you think Paper-Based Board Games are new for you? Please give your opinion.
   你认为纸质版桌游对你来说是新事物吗? 请发表你的意见。

   _____

6. Do you understand the content when you learn through Paper-Based Board Games in the classroom? Why?
   在课堂上时通过纸质版桌游学习的内容, 你是否理解? 为什么?

   _____

7. Do you like Paper-Based Board Games to help you figure out what the science materials are about? Why?
   你喜欢纸质版桌游来帮助你弄清楚什么是科学材料吗? 为什么?

   _____

8. Do you learn a lot after using Paper-Based Board Games in the classroom? Please give examples.
   在课堂上玩纸质版桌游后，你会学到很多吗？ 请举例。

   _____

9. Do you like to use Paper-Based Board Games and explain the contents or answer the questions? Why?
   你喜欢用纸质版桌游解释内容或回答问题吗？ 为什么？

   _____

10. Do you like to use Paper-Based Board Games to list out the science materials from them? Why?
    你喜欢用纸质版桌游列出其中的科学资料吗？ 为什么？

    _____

11. Do you like to work individually or collaboratively? Why?
    你喜欢单独还是一起进行活动？ 为什么？

    _____

12. Do you like to use Paper-Based Board Games with your friends? Why?
    你喜欢和朋友一起玩纸质版桌游吗？ 为什么？

    _____

13. Do you like to engage in group activity to discuss science questions? Why?
    你喜欢参加小组活动讨论科学问题吗？ 为什么？

    _____

14. Do you like to communicate with other group members while you are involved in using Paper-Based Board Games? Why?
    在玩纸质版桌游的同时，你喜欢和其他组员交流吗？ 为什么？

    _____

15. Do you relate the science materials with the usage of Paper-Based Board Games? Why?

    你是否会将科学材料与纸质版桌游的运用联系起来吗？ 为什么？

    _____

16. Do you feel motivated to learn science after the implementation of Paper-Based Board Games? Why?

    实施纸质版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？

    _____

17. Are Paper-Based Board Games different from conventional teaching method? Why?

    纸质版桌游与传统教学方法有什么不同？ 为什么？

    _____

18. Do you like to use Paper-Based Board Games in the next lesson? Why?

    在下一堂课时，你会喜欢用纸质版桌游吗？ 为什么？

    _____

19. Do you like to use Paper-Based Board Games when you try to learn the science materials in the future? Why?

    在往后的日子里，你会喜欢用纸质版桌游来学习科学资料吗？ 为什么？

    _____

20. Would you like other teachers to use Paper-Based Board Games to teach other subjects? Why?

    你会希望其他老师使用纸质版桌游来教导其他科目吗？ 为什么？

    _____

Thank You

谢谢

APPENDIX AB

Interview Protocol

访谈协议

You are invited to be in this research which will identify the social interaction features and evaluate the extent of learning motivation in learning science using Computerised Board Games (CBG) with collaborative learning. To assure the confidentiality and voluntary of yours, you may read the questions provided in the interview protocol before it starts. On top of that, the interviewer also will give special attention to the mode of dressing and appearance which inadvertently shows the maturity and professionalism of a researcher to the interviewees. To make sure that all the feedback can be obtained during the interview process, the researcher will conduct the recording using a recorder and note-taking of the ideas revealed by the interviewees. The entire interview session will take no longer than 20 minutes. For your information, after this interview session ends, the data will be transcribed verbatism, coded and themed according to the research objectives.

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Time of interview 访谈时间: _____

Date 日期: _____

Place 地点: _____

Interviewer 访问者: _____

Interviewee 受访者: _____

Interview Questions 访谈问题:

1. Tell me about yourself.
   介绍一下你自己。

   _____

2. Do you know how to use electronic devices and learn knowledge?
   你知道如何使用电子设备和学习知识吗?

   _____

3. Do you enjoy learning Science? Why?
   你喜欢学习科学吗? 为什么?

   _____

4. What do you think about computerised board games?
   你对电脑版桌游有什么看法?

   _____

5. Do you think computerised board games are new for you? Please give your opinion.
   你认为电脑版桌游对你来说是新事物吗? 请发表你的意见。

   _____

6. Do you understand the content when you learn through computerised board games in the classroom? Why?
   在课堂上时通过电脑版桌游学习的内容, 你是否理解? 为什么?

   _____

7. Do you like computerised board games to help you figure out what the science materials are about? Why?
   你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗? 为什么?

   _____

8. Do you learn a lot after using computerised board games in the classroom? Please give examples.
   在课堂上玩电脑版桌游后，你会学到很多吗？ 请举例。

   _____

9. Do you like to use computerised board games and explain the contents or answer the questions? Why?
   你喜欢用电脑版桌游解释内容或回答问题吗？ 为什么？

   _____

10. Do you like to use computerised board games to list out the science materials from them? Why?
    你喜欢用电脑版桌游列出其中的科学资料吗？ 为什么？

    _____

11. Do you like to work individually or collaboratively? Why?
    你喜欢单独还是一起进行活动？ 为什么？

    _____

12. Do you like to use computerised board games with your friends? Why?
    你喜欢和朋友一起玩电脑版桌游吗？ 为什么？

    _____

13. Do you like to engage in group activity to discuss science questions? Why?
    你喜欢参加小组活动讨论科学问题吗？ 为什么？

    _____

    —

14. Do you like to communicate with other group members while you are involved in using computerised board games? Why?
    在玩电脑版桌游的同时，你喜欢和其他组员交流吗？ 为什么？

    _____

15. Do you relate the science materials with the usage of computerised board games? Why?

    你是否会将科学材料与电脑版桌游的运用联系起来吗？ 为什么？

    _____

16. Do you feel motivated to learn science after the implementation of computerised board games? Why?

    实施电脑版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？

    _____

17. Are computerised board games different from conventional teaching method? Why?

    电脑版桌游与传统教学方法有什么不同？ 为什么？

    _____

18. Do you like to use computerised board games in the next lesson? Why?

    在下一堂课时，你会喜欢用电脑版桌游吗？ 为什么？

    _____

19. Do you like to use computerised board games when you try to learn the science materials in the future? Why?

    在往后的日子里，你会喜欢用电脑版桌游来学习科学资料吗？ 为什么？

    _____

20. Would you like other teachers to use computerised board games to teach other subjects? Why?

    你会希望其他老师使用电脑版桌游来教导其他科目吗？ 为什么？

    _____

Thank You

谢谢

APPENDIX AC

Interview Protocol

访谈协议

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Time of interview 访谈时间: _____

Date 日期: _____

Place 地点: _____

Interviewer 访问者: _____

Interviewee 受访者: _____

Interview Questions 访谈问题:

Introduction

1. Tell me about yourself.
   介绍一下你自己。

   _____

2. Do you know how to use board games and learn knowledge before?
   在这之前，你知道如何使用桌游和学习知识吗?

   _____

3. Do you enjoy learning Science before using Paper-Based Board Games?
   使用纸质版桌游之前，你会喜欢学习科学吗?

   _____

4. Do you think Paper-Based Board Games are new for you? Please give your opinion.
   你认为纸质版桌游对你来说是新事物吗？ 请发表你的意见。

   _____

Learning Motivation

5. Do you understand the content when you learn through Paper-Based Board Games in the classroom compared with previous lesson? Why?
   在课堂上时学习纸质版桌游的内容，和之前的教学活动相比，你是否更加理解呢？为什么？

   _____

6. Do you like Paper-Based Board Games to help you figure out what the science materials are about? Why?
   你喜欢纸质版桌游来帮助你弄清楚什么是科学材料吗？ 为什么?

   _____

7. Do you learn a lot after using Paper-Based Board Games in the classroom? Please give examples.
   在课堂上玩纸质版桌游后，你会学到很多吗？ 请举例。

   _____

8. Do you like to using Paper-Based Board Games to explain the contents or answer the questions? Why?
   你喜欢用纸质版桌游解释内容或回答问题吗？ 为什么？

   _____

9. Do you like to use Paper-Based Board Games to list their science materials? Why?
   你喜欢用纸质版桌游列出其中的科学资料吗？ 为什么？

   _____

10. Do you relate the science materials with the usage of Paper-Based Board Games? Why?
    你是否会将科学材料与纸质版桌游的运用联系起来吗？ 为什么？

    _____

11. Do you feel motivated to learn science after implementing Paper-Based Board Games? Why?
    实施纸质版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？

    _____

12. Are Paper-Based Board Games different from conventional teaching methods? Why? 纸质版桌游与传统教学方法有什么不同？ 为什么？

    _____

Social Interaction

13. Do you like to work individually or collaboratively? Why?
    你喜欢单独还是一起进行活动？ 为什么？

    _____

14. Do you like to use Paper-Based Board Games with your friends? Why?
你喜欢和朋友一起玩纸质版桌游吗？ 为什么？

_____

15. Do you like to engage in a group activity to discuss science questions? Why?
你喜欢参加小组活动讨论科学问题吗？ 为什么？

_____

16. Do you like to communicate with other group members while you are involved in using Paper-Based Board Games? Why?
在玩纸质版桌游的同时，你喜欢和其他组员交流吗？ 为什么？

_____

Conclusion

17. Do you like to use Paper-Based Board Games in the next lesson? Why?
在下一堂课时，你会喜欢用纸质版桌游吗？ 为什么？

_____

18. Do you like to use Paper-Based Board Games when you try to learn science materials in the future? Why?
在往后的日子里，你会喜欢用纸质版桌游来学习科学资料吗？ 为什么？

_____

19. Would you like other teachers to use Paper-Based Board Games to teach other subjects? Why?
你会希望其他老师使用纸质版桌游来教导其他科目吗？ 为什么？

_____

Thank You

谢谢

APPENDIX AD

Interview Protocol

访谈协议

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Interviewer 访问者: _____

Interviewee 受访者: _____

Interview Questions 访谈问题:

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1. Tell me about yourself.
   介绍一下你自己。

   _____

2. Do you know how to use electronic devices and learn knowledge before?
   在这之前，你知道如何使用电子设备和学习知识吗?

   _____

3. Do you enjoy learning Science before using computerised board games?
   使用电脑版桌游之前，你会喜欢学习科学吗?

   _____

4. Do you think computerised board games are new for you? Please give your opinion.
   你认为电脑版桌游对你来说是新事物吗? 请发表你的意见。

   _____

Learning Motivation

5. Do you understand the content when you learn through computerised board games in the classroom compared with previous lesson? Why?
   在课堂上时学习电脑版桌游的内容，和之前的教学活动相比，你是否更加理解呢? 为什么?

   _____

6. Do you like computerised board games to help you figure out what the science materials are about? Why?
   你喜欢电脑版桌游来帮助你弄清楚什么是科学材料吗? 为什么?

   _____

7. Do you learn a lot after using computerised board games in the classroom? Please give examples.
   在课堂上玩电脑版桌游后，你会学到很多吗？ 请举例。

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8. Do you like to using computerised board games to explain the contents or answer the questions? Why?
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   _____

10. Do you relate the science materials with the usage of computerised board games? Why?
    你是否会将科学材料与纸质版桌游的运用联系起来吗？ 为什么？

    _____

11. Do you feel motivated to learn science after implementing computerised board games? Why?
    实施电脑版桌游这个教学法之后，你是否有学习科学的动力？ 为什么？

    _____

12. Are computerised board games different from conventional teaching methods? Why? 电脑版桌游与传统教学方法有什么不同？ 为什么？

    _____

Social Interaction

13. Do you like to work individually or collaboratively? Why?
    你喜欢单独还是一起进行活动？ 为什么？

    _____

14. Do you like to use computerised board games with your friends? Why?
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_____

15. Do you like to engage in a group activity to discuss science questions? Why?
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_____

16. Do you like to communicate with other group members while you are involved in using computerised board games? Why?
在玩电脑版桌游的同时，你喜欢和其他组员交流吗？ 为什么？

_____

Conclusion

17. Do you like to use computerised board games in the next lesson? Why?
在下一堂课时，你会喜欢用电脑版桌游吗？ 为什么？

_____

18. Do you like to use computerised board games when you try to learn science materials in the future? Why?
在往后的日子里，你会喜欢用电脑版桌游来学习科学资料吗？ 为什么？

_____

19. Would you like other teachers to use computerised board games to teach other subjects? Why?
你会希望其他老师使用电脑版桌游来教导其他科目吗？ 为什么？

_____

Thank You

谢谢

APPENDIX AE

Phase One: Familiarisation with the Data

Transcripts from a Few Participants

PBBG G27P2:

After…emm…playing this board games…I think I always to…work… hmm…collaboratively…as four of us… form a team and play it…

Absolutely, teacher! I am really enjoy to use this…ah…board games… hmm…with my group members! We can discuss and communicate in a group and…emm… make this board game successfully!

Yes, teacher….I am an active person…as I like to engage with them… to discuss science questions…because it can help me to…hmm...mm… master those new knowledge easily…

Hmm…yes…I think I like to do it…as we can have the chances…emm…to communicate while using this board games…so that we can solve… hmm…the science questions together…It is a lot of fun with them!

PBBG G10P3:

Yup, teacher….I think I am more prefer…hmm… to work…emm… collaboratively…because this learning method is much fun!

Yes, teacher…for me, ah-ha…I like to use this board game and share… with my friends…It is because we can play and learn science together!

Yup…I always prefer to…emm….engage in a group activity. So, I… can discuss with my group members too…hmm…the science question.

Hmm… no doubt…I always like to…emm…communicate with… other group members, ah-ha…especially when we try to…solve the… hmm…the questions in the science classroom…

PBBG G33P1:

Yes, teacher… for me, I am willing to…ehmm…work with others in the classroom…because this can increase my understanding…ehmm… when discussing with my friends in the science classroom…

Yes, I do! I like…ehmm….to apply Paper-Based Board Games…ah… and play with my friends…It can provide me a lot of time and learn… hmm…together with them….

For me, I am really like to…ehmm…engage in a group activity…in… ah-ha…the science classroom so that…I can discuss the questions with my friends…hmm…in the same group…

Yes…I always prefer to…ehmm….communicate with other group members…especially when we are..ah…using this board game….so that…we can enjoy the learning environment and master….ehmm… the knowledge better…

PBBG G50P1:

Yup, I am personally like to…hmm….work collaboratively…It is… ehmm…because we can learn science concepts together…while… having fun to play this board game…

Yup, I like…to use this board game….which is Paper-Based Board Game…hmm….with my friends…so that we can enjoy science learning…ah-ha…in the classroom…

I am really like to engage….hmm…in a group activity…with my…. friends…to discuss those science questions…This scenario can give me more opportunities…ehmm…to learn new knowledge….

Under this condition, I am really…ah…like to communicate with… other group members…especially when we are involved in applying board game…It is because it will create condusive learning…ehmm... for us to learn science…

PBBG G40P3:

For me, I think…I prefer to work collaboratively…It is because…I… enjoy to talk with my friends…ehmm…and learn together…

Yes….absolutely…I am really like to use…ehmm…this kind of... board game…with my friends…because I like to learn the science… ehmm…knowledge through gaming method…as this board game is... really interesting to play…

Yes…for me, I like to engage with my friends in the group activity, as…ehmm….we can discuss those science questions while playing this board game in the classroom…It is because playing within group is… hmm…more interesting and enjoyable…

Absolutely, teacher! I like to communicate with other group member, especially when I am involved in utilizing this board game. It is eh… because we can help each other in solving the questions…

CBG G32P1:

Of course, teacher! I think that I like to work collaboratively in the classroom…It is because a lot of fun when I am playing and learning with my friends through…ehmm…this kind of board game…

Definitely…I like to use this version of board game…ah…to play and learn with my friends….because it is my first experience to do so…It is fun to apply!

Yup…I like to engage myself in a group activity…as we can discuss those science questions together…so that I can understand them in a funnier way…

*Of course…I prefer to have communication with…*hmm..other group members, *especially…hmm…when we are involved in applying this ….ehmm…computerized board game….It is because we can discuss with each other…and then master those knowledge better…*

CBG G44P4:

Yes…of course…I like to work collaboratively…because I can play and learn together with my group members…if compared with just to work individually…

Definitely…I like to apply this version of board game, ehmm…which is computerized board game…with my friends in the classroom…For me, we can discuss and learn the new knowledge together while play this board game…It is a lot of fun!

Yes…I always like to engage…ehmm….in a group activity…so that we can discuss those science questions….Furthermore, we can play and then…ehmm…learn together with this board game in the class…

Yes..I like to communicate with others while we are in the classroom. Then…ehmm…with this board game, I can always communicate and play with them…so that I can understand the new knowledge better…

CBG G16P3:

Be honest….I myself like to work collaboratively…..it is because I… would like to play and learn the science knowledge with others…so that it will be fun together…

Absolutely, teacher…I like to play computerized board games…with my friends…because this scenario allows us to play and learn in a fun way…

Yes…I am an active person…So, I always like to engage in a group activity…so that I can discuss science questions with others…it is… hmm…because learning together is much much fun than learning… alone in the classroom…

For me, yes…as I like to communicate with other group members… while I am given the chances to involve in utilizing this board game... It is because while I play it, other group members will help me out… so that we can complete the task together…

CBG G23P2:

Yes…I am more….hmm….prefer to work collaboratively…It is… because…ah…I can learn and play together with my friends…as we can master those science knowledge in a better way…

Hmm….for me…I like to apply this board game with my friends… It is because….we can learn and discuss together during the board game in the classroom…

Yup…I prefer to engage in a group activity…to discuss with my...eh.. my friends…about those science questions…so that we can play and learn together in a fun way…

Yes…of course…I like to communicate with others when we are… ehmm…using this computerized board game…because I can receive other ideas from them at that moment…

CBG G51P1:

Yes...teacher…as I have mentioned before…I myself like to work… emm…collaboratively…because we can learn and play at the same time…in science learning in the classroom…

Ehmm….yup…I think I like to use this computerized board game… especially with my friends…it is because playing with them, then I… hmm…can learn and master those scientific skills better…

Yup…as I know, I am an active person…so I can engage in a group activity with my group members…so that we can be together and… emm…discuss the science questions…Hence, it is better for us to do like this…

Yes, teacher…I would like to communicate with other group member …hmm…especially when I am given the chances to use this kind of board game with my friends…so that we can together to solve those tasks within the group…ehmm…achieve the learning objectives…

Phase Two: Generating Initial Codes

Coded Transcripts (PBBG and CBG Partcipants)	
Transcript	**Codes**
emm…playing this board games…I think I always to…work… hmm…collaboratively…(PBBG G27P2)	Collaboration
We can discuss and communicate in a group and…emm… make this board game successfully! (PBBG G27P2)	Collaboration
as I like to engage with them… to discuss science questions…(PBBG G27P2)	Communication
…as we can have the chances…emm…to communicate while using this board games…(PBBG G27P2)	Communication
I think I am more prefer…hmm… to work…emm… collaboratively…(PBBG G10P3)	Collaboration
for me, ah-ha…I like to use this board game and share… with my friends…(PBBG G10P3)	Collaboration
I always prefer to…emm….engage in a group activity. So, I… can discuss with my group members too…hmm…(PBBG G10P3)	Communication
no doubt…I always like to…emm…communicate with…	Communication

other group members…(PBBG G10P3)	
… for me, I am willing to…ehmm…work with others in the classroom…(PBBG G33P1)	Collaboration
I like…ehmm….to apply Paper-Based Board Games…ah… and play with my friends…(PBBG G33P1)	Collaboration
I am really like to…ehmm…engage in a group activity…in… ah-ha…the science classroom so that…(PBBG G33P1)	Communication
I always prefer to…ehmm….communicate with other group members…especially when we are..ah…using this board game….(PBBG G33P1)	Communication
…hmm….work collaboratively…It is… ehmm…because we can learn science concepts together…(PBBG G50P1)	Collaboration
…to use this board game….which is Paper-Based Board Game…hmm….with my friends…(PBBG G50P1)	Collaboration
I am really like to engage….hmm…in a group activity…with my…. friends…(PBBG G50P1)	Communication
I am really…ah…like to communicate with… other group members…especially when we are involved in applying board game…(PBBG G50P1)	Communication
…I prefer to work collaboratively…It is because…I… enjoy to talk with my friends…(PBBG G40P3)	Collaboration
absolutely…I am really like to use…ehmm…this kind of… board game…with my friends…(PBBG G40P3)	Collaboration
for me, I like to engage with my friends in the group activity, as…ehmm….(PBBG G40P3)	Communication
I like to communicate with other group member, especially when I am involved in utilizing this board game…(PBBG G40P3)	Communication
I think that I like to work collaboratively in the classroom…(CBG G32P1)	Collaboration
I like to use this version of board game…ah…to play and learn with my friends…(CBG G32P1)	Collaboration
I like to engage myself in a group activity…as we can discuss those science questions together…(CBG G32P1)	Communication
I prefer to have communication with…hmm...other group members, especially…hmm…(CBG G32P1)	Communication
of course…I like to work collaboratively…(CBG G44P4)	Collaboration
I like to apply this version of board game, ehmm…which is computerized board game…with my friends in the	Collaboration

classroom…(CBG G44P4)	
Yes…I always like to engage…ehmm….in a group activity…(CBG G44P4)	Communication
Yes...I like to communicate with others while we are in the classroom…(CBG G44P4)	Communication
….I myself like to work collaboratively…..it is because I…(CBG G16P3)	Collaboration
…I like to play computerized board games…with my friends…(CBG G16P3)	Collaboration
So, I always like to engage in a group activity…so that I can discuss science questions with others…(CBG G16P3)	Communication
yes…as I like to communicate with other group members…(CBG G16P3)	Communication
I am more….hmm….prefer to work collaboratively…It is… because…(CBG G23P2)	Collaboration
for me…I like to apply this board game with my friends…(CBG G23P2)	Collaboration
I prefer to engage in a group activity…to discuss with my...eh.. my friends…(CBG G23P2)	Communication
of course…I like to communicate with others when we are… ehmm…using this computerized board game…(CBG G23P2)	Communication
I myself like to work… emm…collaboratively…(CBG G51P1)	Collaboration
yup…I think I like to use this computerized board game… especially with my friends…(CBG G51P1)	Collaboration
as I know, I am an active person…so I can engage in a group activity with my group members…(CBG G51P1)	Communication
I would like to communicate with other group member …hmm…especially when I am given the chances to use this kind of board game with my friends…(CBG G51P1)	Communication

Phase Three: Generating Themes

Some Codes with Illustrative Data Extracts

Collaboration: Work Collaboratively	**Collaboration: Playing Board Games with Friends**	**Communication: Engagement**	**Communication: Group Involvement**
emm…playing this board games…I think I always to…work… hmm…collaboratively…(PBBG G27P2)	*We can discuss and communicate in a group and…emm… make this board game successfully! (PBBG G27P2)*	*as I like to engage with them… to discuss science questions…(PBBG G27P2)*	*…as we can have the chances…emm…to communicate while using this board games…(PBBG G27P2)*
I think I am more prefer…hmm… to work…emm… collaboratively…(PBBG G10P3)	*for me, ah-ha…I like to use this board game and share… with my friends…(PBBG G10P3)*	*I always prefer to…emm….engage in a group activity. So, I… can discuss with my group members too…hmm…(PBBG G10P3)*	*no doubt…I always like to…emm…communicate with… other group members…(PBBG G10P3)*
… for me, I am willing to…ehmm…work with others in the classroom…(PBBG G33P1)	*I like…ehmm….to apply Paper-Based Board Games…ah… and play with my friends…(PBBG G33P1)*	*I am really like to…ehmm…engage in a group activity…in… ah-ha… the science classroom so that…(PBBG G33P1)*	*I always prefer to…ehmm …communicate with other group members… especially when we are..ah…using this board game….(PBBG G33P1)*
…hmm..work collaboratively… It is… ehmm…because we can learn science concepts together…(PBBG G50P1)	*…to use this board game….which is Paper-Based Board Game…hmm….with my friends…(PBBG G50P1)*	*I am really like to engage….hmm…in a group activity…with my…. friends…(PBBG G50P1)*	*I am really…ah…like to communicate with… other group members…especially when we are involved in applying board game…(PBBG G50P1)*
…I prefer to work collaboratively…It is because…I… enjoy to talk with my friends…(PBBG G40P3)	*absolutely…I am really like to use…ehmm…this kind of… board game…with my friends…(PBBG G40P3)*	*for me, I like to engage with my friends in the group activity, as…ehmm….(PBBG G40P3)*	*I like to communicate with other group member, especially when I am involved in utilizing this board game…(PBBG G40P3)*
I think that I like to	*I like to use this*	*I like to engage*	*I prefer to have*

work collaboratively in the classroom…(CBG G32P1)	*version of board game…ah…to play and learn with my friends…(CBG G32P1)*	*myself in a group activity…as we can discuss those science questions together…(CBG G32P1)*	*communication with…hmm...other group members, especially…hmm…(CBG G32P1)*
of course…I like to work collaboratively…(CBG G44P4)	*I like to apply this version of board game, ehmm…which is computerized board game…with my friends in the classroom…(CBG G44P4)*	*Yes…I always like to engage…ehmm….in a group activity…(CBG G44P4)*	*Yes...I like to communicate with others while we are in the classroom…(CBG G44P4)*
….I myself like to work collaboratively…..it is because I…(CBG G16P3)	*…I like to play computerized board games…with my friends…(CBG G16P3)*	*So, I always like to engage in a group activity…so that I can discuss science questions with others…(CBG G16P3)*	*yes…as I like to communicate with other group members…(CBG G16P3)*
I am more….hmm….prefer to work collaboratively…It is… because…(CBG G23P2)	*for me…I like to apply this board game with my friends…(CBG G23P2)*	*I prefer to engage in a group activity…to discuss with my...eh.. my friends…(CBG G23P2)*	*of course…I like to communicate with others when we are… ehmm…using this computerized board game…(CBG G23P2)*
I myself like to work… emm…collaboratively…(CBG G51P1)	*yup…I think I like to use this computerized board game… especially with my friends…(CBG G51P1)*	*as I know, I am an active person…so I can engage in a group activity with my group members…(CBG G51P1)*	*to communicate with othe group member… hmm…especially I am given the chances to…with my friends…(CBG G51P1)*

APPENDIX AF

Phase One: Familiarisation with the Data

Transcripts from a Few Participants

PBBG G27P2:

Ah-ha… I think …I can understand … the content when I apply this…board games. It is because… I can play and learn… emm.. at the same time… It is more fun!

Yes, teacher… I like this board games… as it really can help me to… learn and figure out… emm…what the science material is about… It is because… I was given the chances to …hmm…learn new knowledge... this time… so, I can master it faster…

Sure, teacher….This board games is really helping me out to learn… a lot… For example…I can master… emm….what are renewable energy and non-renewable energy easily…through this board games…

Yes…teacher… I prefer…emm…to use this board games…ah-ha… explain the contents, hmm… especially when I try to answer questions. Because it is more fun…to discuss with my… group members… together…and can learn it faster…

Yes, teacher…I do like… to use this board game to…hmm… list the… science materials…For example, I can understand better about…the… hmm…classification of materials in Chapter 8…

Be honest…emm..I do relate the science materials….emm with this… board games…because it can make me to…understand and master… the knowledge in this science classroom…

Yes…teacher…I feel more motivated…to learn science topic… once I apply this board games…because it can give me to play…and… learn science topics together with my friends together… interesting!

Ehmm…yes…it is totally different with those…emm…conventional… teaching method…I think that this board games are more fun…and… we can learn and play together…

PBBG G10P3:

To be honest, emm…I can understand the science content…ah-ha… when I learn them with the help of…this board games if really… want to compare with previous lesson. It is because I can learn it in am….a... funnier way…

Yes, teacher…I do like this board game…one of the reasons is to em… figure out what the science material…because it is emm…so much fun to apply it while learning science emm…at the same time…

Yup…It is really helpful…emm…for me…For example, I can master hmm…the reflection of light after playing this board games…as I can understand this concept very well…

In my opinion, emm…I like to use Paper-Based Board Games…hm… to explain the contents to my group members or answering questions… It is because that…hmm…I can be more understand about it and em… share with them…

I like to…use Paper-Based Board Games to list science materials. Em.. for this case, I can hmm…play it and learn the examples of energy in… emm….Chapter 7, which are renewable and non-renewable energy…

Yup…emm…I can relate those science materials…hmm…with this… board game in the classroom…Through this board game, I can know… hmm… the concepts better…

Be honest with teacher, yup…I feel much motivated after playing… emm…this board game in learning science…because emm…I'm much enjoy playing and learning knowledge in the classroom…

Yup, teacher…In my opinion, this kind of board games… emm…is… different with conventional teaching method…hmm..in the classroom... because I feel like more participated in learning science…emm… through this board game…

PBBG G33P1:

Yes, teacher…I am really understand…emm…the learning content… once I am exposed to Paper-Based Board Game…if compared with… those previous lessons… For me, it is much easier for me…hmm…to learn the science topics…

Yup…I do like this kind of board game…as it really helps me to… hmm…figure out those science materials…so that I can have a clearer picture of them when playing with my group members…

In my opinion, ehmm….I think I have learnt a lot…after using this… hmm….board game in the classroom…Examples, I can easily know… about the types of energy while playing it with my friends…

Yes, I do like to use Paper-Based Board Game in the classroom…as I can…ehmm…explain the content that I learnt and…hmm…able to… answer the questions… Meanwhile, I also can play and learn through... this board game…

Yup, I like to use this version of board game…emm…so that…I can… list those science materials…For instance, there are a lots of energy… hmmm…that we can learn from Chapter 7…Hence, I can easily know it after applying Paper-Based Board Games in the classroom…

Absolutely, teacher…I can relate those science materials with the… hmm… help of this board game so that…emm….I can understand it… better…

During the application of this board game, I always…emm….feel… motivated…to learn the science topics…It is because this board game gives me more chances to play and learn with my friends…

Yes, in my opinion…Paper-Based Board Games are totally different… hmmm…from those conventional teaching methods, including…em… chalk and talk in the classroom…It is because we are given chances… hmm…to learn the science knowledge by our own…

PBBG G50P1:

After…ehmm…I was exposed to…Paper-Based Board Game, as it… hmm…compared to previous lessons…I think I can understand the… ah..content easily…

Absolutely… I do like this kind of board games…as it can help me… hmm…to figure out those science materials…it is because I can… ehmm….better understand those concepts in the classroom…

I think that I can learn a lot of science concepts…hmm…after playing this kind of board game…For instance, I can understand the concept of... ah…ha…refraction of light in…ehmm…Chapter 5…

Yes, I like to use…hmm…Paper-Based Board Games….since it can help me…ah…to explain those learning contents…and then…ehmm.. to answer the questions….When I play it, I have tried to answer a lot of questions….ehmm…in the slot…

Besides that…ehmm….I also prefer to use this board game….hmm… to list those science materials….for this, I can master it in a funnier… ehmm…way in the classroom…

Positively, teacher…I can relate this board game…ehmm…with the science materials…hmm….in the classroom…For instance, I can… emm…to understand the concept of natural and man-made materials…

Yes, I always…ehmm…feel motivated to learn those…ah…science topics….especially when I was exposed to…this board game…so that I can learn and play with my friends…

In my opinion…absolutely, this board games are…ehmm…different from conventional teaching method in the…ehmm…science class… It is because we can have two-way communication with each other…

PBBG G40P3:

In my opinion, I think with this board game…ehmm…I can know… ah…more about the learning content in science topics…as compared with previous lesson…Hence, it is quite interesting for me to do so…

Yes…through this board game too…hmm…I also would like to say that…ehmm…it can help me to figure out those science materials…. because it make me feel fun and excited to…emm…learn it more…

Yes, teacher…I learn a lot after utilizing this kind of board game….as I have gained the knowledge, such as….ehmm…the sources of ah… energy….in Chapter 7…

Definitely…..I like to apply this version of board game…as I am able to…hmm….to explain the learning contents in science textbook… then, I also can answer the questions after playing this board game…

In addition….ah…ha…I am really like to use….this board game to… ehmm… to list out the science materials…For example, what I have learnt was about the differences between natural and man-made… hmm….materials…

Yup…I can relate the science materials….ah..ha…in the classroom… after applying Paper-Based Board Game…It is because I am much… hmm…easier to master the concepts…

Of course, teacher…In my opinion…I feel motivated to learn science while I am playing this board game…with my friends…because I can discuss and play with them, at the same time…also learn the new… knowledge…

Yup…this kind of board game….is totally different with…ehmm…. the conventional teaching method before…as that approach is more focused on…my teacher before…

CBG G32P1:

Yes, teacher! I can understand…ehmm…those contents when I am… trying to apply this computerized board game, especially when it… compared with conventional teaching method before… It is because this board game can give me opportunities to play and learn…emm… with other friends…

Yup…I do like this…ehmm… computerized board game…, as it can help me to figure out those science materials…because it directly… hmm….give me the clearer picture to master….

Absolutely, teacher…after using this kind of board game…ehmm… I learn a lot about science topics…ah…in the class…For instance… I can understand better…about the concepts of forming shadow…

Yup, teacher…I like to apply this board game in the classroom…I am also use it and able to…hmm…explain the science contents…and answer the questions…examples…emm…the reflection of light in… hmm…subtopic 5.1…

Yes…in my opinion, I am quite prefer to use…computerized board games to do some works, such as…hmm…listing out the science… materials….for instance, I can apply it and learn the similarities and differences between energy…

Yes…through the implementation of…ehmm…this version of board games….I can relate the science materials better…meanwhile, I also able to understand those concepts with the examples too…

Ah…ha….yes..I feel motivated a lot when I try to learn science... after using this Computerized Board Games. It is because I have the opportunities to learn together with my group members….then I can master those knowledge better…

Yes…For me, this board game is different from those conventional… ehmm…teaching method…It is because I can differentiate that this game always involves me and other friends to play and learn science together…hmm…and then it is not happening for conventional…em.. teaching method before…

CBG G44P4:

For me, I think that I can understand…hmm…the learning content of science….after applying the computerized board game…especially if compared with previous lesson…because it always involves the...em.. me and other group members to play and learn science together…

Be honest, I like computerized board game…especially to help me in figuring out what the science materials…because this kind of board game allows me to understand better in the class…

Yup…I do learn a lot of science content…once we have used this… emm…board game…For example, I have memorized the concept of materials in Chapter 8, as…ehmm…there are two types of materials...

In my opinion…I myself…ehmm…like to use computerized board games…especially when I am…trying to explain the contents…or… ehmm…to answer the questions…Under this condition, I can play… and then…ehm…learn to the knowledge based on the slots that I… hmm…have selected during the board game…

Yup…I like to use or apply…hmm…computerized board game…so... I am able to list science materials…for example, with the help of this board game, then…I can…understand the similarities and differences of energy better…

Yes…I can relate science materials after applying this kind of board game…because I have more understanding in learning them with my friends in the classroom…

Absolutely…I have a lot of motivation…after I was given the chance to apply computerized board game with my friends…because it has give me chances to play and learn with them…It is fun!

In my opinion, yes…this kind of board games is different from ehm... conventional teaching method…it is because this teaching method… hmm…gives me lots of chances to play and learn with my friends…

CBG G16P3:

Emm….I can say that I do understand…hmm…the science contents while I am applying this board game…if compared with previous… lesson…It is because for previous lesson, what I was doing only… emm….listen to teacher's instruction and never play and learn with my friends like this before…

Yup…for me, I like to play this computerized board game…so that… it can assist me to…ehmm…figure out those science materials…it is because this board game can allow me to learn more about science contents, such as…emm…reflection of light and types of materials…

Yes, teacher….I am really learning a lot after using computerized… ehmm….board game…ah…in the classroom…For instance, what I have learnt were…emm…renewable energy and non-renewable…. energy….besides that, I also have learnt types of materials from… emm…Chapter 8…

Yes….in my opinion…I like to apply this kind of board game, which is computerized board game…so that I can explain those contents… and able to answer the questions….Under this condition, I also able to…ehmm…then, I can understand it better and apply in the daily life……

For me, I would like to use this board game in the science classroom.. as I was given the opportunity to list the science materials….then, I… also can use this board game to learn and master those materials in Chapter 8 in the class…

Yup…definitely…I was given the opportunity to relate the science… ehmm…materials…through this kind of board game…Hence, I think this board game can help me to master those skills better with my… ehmm…group members…in the classroom…

For me, yes…I feel motivated…ehmm…to learn more knowledge… hmm…about science after playing this board game with my friends… It is because this board game encourages me to play and learn with… hmm…my group members…so that…we can master those skills… better…

Yes….I am totally agree with this…as computerized board games are different with conventional teaching method…It is because the ways to teach the students are different….for this board game, the students always engage in the group activity and learn science, instead of… ehmm…conventional teaching method only involves teacher to…eh.. control the classroom….

CBG G23P2:

Ehmm….for me, I think I can understand the learning content better... when I am applying this board game in the classroom….hmm…if… compared with previous lessons…It is because with this board game, I can learn the knowledge together with my friends….as we also can play together…It is so much fun!

Yup, I myself like to apply this computerized board game….so that I can figure out those science materials….For instance, what I can do is to learn the types of materials in Chapter 8 through this board game… hmm…so that I can easily to master the learning contents…

Yup…I have to admit that after utilizing computerized board game, I have learnt a lot of science knowledge…For examples, I have gained the knowledge about subtopic 5.1, which is 'Light Travels in a Straight Line', as shadow can be formed once the object…ehm…is… opaque…

Hmm…in my own opinion….I like to apply computerized board game….so that I can explain the contents…and then answer those… emm…questions in the science classroom. Hence, I prefer teacher to use this board game and teach science topics with us again…

Yes, I do….as this kind of board game can be used to…ehmm… list the science materials…For example, in Chapter 8, I have learnt that there are two types of materials, which are natural and man-made…

Hmm…. through this board game, I am able to relate science material in the classroom…It is because I have clearer picture to master those knowledge with my friends….

Yup…I feel motivated to learn science…ehmm…after using this… board game to learn science…so that I like this subject later…

For me…ehm…yes…absolutely….this board game is different with conventional teaching method…One of the main differences is the… way of teaching, as we can play and learn at the same time through… hmm…this board game…if compared with conventional teaching… mm…method….

CBG G51P1:

Emm…I understand the learning content after I apply this kind of… board game….hmm….in the classroom…if compared with previous lesson…It is because I realize that it is ah….much easier for me to… understand those contents…

Yup….I think I like this computerized board game…as it can really… help me to figure out those science materials….so that I can get know of it better……

As I know…yup…after using this computerized board game…I am… really learn a lot…example…is I have gained the knowledge about refraction of light and light can travel in a straight line…

hmm...I think I like to apply this board game…which is computerized board game…especially try to explain those science contents…at the same time…I also able to

answer the questions…for this case, what I have learnt is using this board game to understand more about the… hmm…concepts of energy and so forth…

Through this…ehmm…ah…computerized board game…I like to use it…so that I can list the science materials…

Yup...for me…I can relate the science materials…with the help of… computerized board game….mm…in the classroom…it is because… I can play and learn with my other group members…so we can…mm ya…master those knowledge in a better way…

Absolutely…I am really feel motivated in learning science…after this ah….computerised board game…because…what is important for me is I can learn and work collaboratively with my friends…it is much easier for me to memorize those scientific facts…

Yes, teacher…for me, this computerized board game is totally...ya… different from those conventional teaching methods…It is because… the way of teaching us is different with each other. For this board… ehmm…game, we are given the chances to learn science…through play, but for conventional teaching method…we just sit there and…. hmm…listen…

Phase Two: Generating Initial Codes

Coded Transcripts (PBBG and CBG Partcipants)	
Transcript	**Codes**
I think …I can understand…the content when I apply this…board games..(PBBG G27P2)	Task Orientation
I like this board games… as it really can help me to… learn and figure out… emm…what the science material is about…(PBBG G27P2)	Openness and Acceptance
board games is really helping me out to learn… a lot…(PBBG G27P2)	Motivational Management

I prefer…emm…to use this board games…ah-ha… explain the contents, hmm… especially when I try to answer questions. (PBBG G27P2)	Openness and Acceptance
I do like… to use this board game to…hmm… list the… science materials…(PBBG G27P2)	Openness and Acceptance
emm..I do relate the science materials….emm with this… board games…(PBBG G27P2)	Task Orientation
I feel more motivated…to learn science topic… once I apply this board games…(PBBG G27P2)	Motivational Management
yes…it is totally different with those…emm…conventional… teaching method…(PBBG G27P2)	Openness and Acceptance
…I can understand the science content…ah-ha… when I learn them with the help of…this board games if really…(PBBG G10P3)	Task Orientation
I do like this board game…one of the reasons is to em… figure out what the science material…(PBBG G10P3)	Openness and Acceptance
It is really helpful…emm…for me…For example, I can master hmm…(PBBG G10P3)	Motivational Management
emm…I like to use Paper-Based Board Games…hm… to explain the contents to my group members or answering questions…(PBBG G10P3)	Openness and Acceptance
use Paper-Based Board Games to list science materials. Em.. (PBBG G10P3)	Openness and Acceptance
emm…I can relate those science materials…hmm…with this… board game…(PBBG G10P3)	Task Orientation
yup…I feel much motivated after playing… emm…this board game in learning science…	Motivational Management
this kind of board games… emm…is… different with conventional teaching method…hmm..in the classroom...(PBBG G10P3)	Openness and Acceptance
I am really understand…emm…the learning content… once I am exposed to Paper-Based Board Game…(PBBG G33P1)	Task Orientation
I do like this kind of board game…as it really helps me to… hmm…(PBBG G33P1)	Openness and Acceptance
ehmm….I think I have learnt a lot…after using this… hmm….board game in the classroom…(PBBG G33P1)	Motivational Management
Yes, I do like to use Paper-Based Board Game in the classroom…as I can…ehmm…(PBBG G33P1)	Openness and Acceptance

I like to use this version of board game…emm…so that…I can… list those science materials…(PBBG G33P1)	Openness and Acceptance
I can relate those science materials with the… hmm… help of this board game so that…(PBBG G33P1)	Task Orientation
I always…emm….feel… motivated…to learn the science topics…(PBBG G33P1)	Motivational Management
in my opinion…Paper-Based Board Games are totally different… hmmm…from those conventional teaching methods, including…em…(PBBG G33P1)	Openness and Acceptance
…I think I can understand the… ah..content easily…(PBBG G50P1)	Task Orientation
I do like this kind of board games…as it can help me… hmm…to figure out those science materials…(PBBG G50P1)	Openness and Acceptance
I think that I can learn a lot of science concepts…hmm…after playing this kind of board game…(PBBG G50P1)	Motivational Management
I like to use…hmm…Paper-Based Board Games….since it can help me…ah…to explain those learning contents…(PBBG G50P1)	Openness and Acceptance
ehmm….I also prefer to use this board game….hmm… to list those science materials….(PBBG G50P1)	Openness and Acceptance
I can relate this board game…ehmm…with the science materials…(PBBG G50P1)	Task Orientation
…ehmm…feel motivated to learn those…ah…science topics….especially when I was exposed to…this board game…(PBBG G50P1)	Motivational Management
absolutely, this board games are…ehmm…different from conventional teaching method in the…ehmm…science class…(PBBG G50P1)	Openness and Acceptance
I think with this board game…ehmm…I can know… ah…more about the learning content in science topics…(PBBG G40P3)	Task Orientation
through this board game too…hmm…I also would like to say that…ehmm…it can help me to figure out those science materials….(PBBG G40P3)	Openness and Acceptance
I learn a lot after utilizing this kind of board game….as I have gained the knowledge (PBBG G40P3)	Motivational Management
I like to apply this version of board game…as I am able to…hmm….to explain the learning contents in science textbook…(PBBG G40P3)	Openness and Acceptance

ah…ha…I am really like to use….this board game to… ehmm… to list out the science materials…(PBBG G40P3)	Openness and Acceptance
Yup…I can relate the science materials….ah..ha…in the classroom… after applying Paper-Based Board Game…(PBBG G40P3)	Task Orientation
In my opinion…I feel motivated to learn science while I am playing this board game…with my friends…(PBBG G40P3)	Motivational Management
Yup…this kind of board game….is totally different with…ehmm…. the conventional teaching method before…(PBBG G40P3)	Openness and Acceptance
can understand…ehmm…those contents when I am… trying to apply this computerized board game, especially when it… (CBG G32P1)	Task Orientation
I do like this…ehmm… computerized board game…, as it can help me to figure out those science materials…(CBG G32P1)	Openness and Acceptance
after using this kind of board game…ehmm… I learn a lot about science topics…ah…in the class…For instance…(CBG G32P1)	Motivational Management
I like to apply this board game in the classroom…I am also use it and able to…hmm…explain the science contents…(CBG G32P1)	Openness and Acceptance
I am quite prefer to use…computerized board games to do some works, such as…hmm…listing out the science… materials….(CBG G32P1)	Openness and Acceptance
ehmm…this version of board games….I can relate the science materials better…(CBG G32P1)	Task Orientation
Ah…ha….yes..I feel motivated a lot when I try to learn science... after using this Computerized Board Games. (CBG G32P1)	Motivational Management
For me, this board game is different from those conventional… ehmm…teaching method…(CBG G32P1)	Openness and Acceptance
I think that I can understand…hmm…the learning content of science….after applying the computerized board game…(CBG G44P4)	Task Orientation
I like computerized board game…especially to help me in figuring out what the science materials…(CBG G44P4)	Openness and Acceptance
I do learn a lot of science content…once we have used this… emm…board game…(CBG G44P4)	Motivational Management
I myself…ehmm…like to use computerized board games…especially when I am…trying to explain the	Openness and Acceptance

contents…or…(CBG G44P4)	
I like to use or apply…hmm…computerized board game…so... I am able to list science materials…(CBG G44P4)	Openness and Acceptance
I can relate science materials after applying this kind of board game…(CBG G44P4)	Task Orientation
I have a lot of motivation…after I was given the chance to apply computerized board game with my friends…(CBG G44P4)	Motivational Management
yes…this kind of board games is different from ehm... conventional teaching method…(CBG G44P4)	Openness and Acceptance
I can say that I do understand…hmm…the science contents while I am applying this board game…(CBG G16P3)	Task Orientation
for me, I like to play this computerized board game…so that… it can assist me to…ehmm…(CBG G16P3)	Openness and Acceptance
teacher….I am really learning a lot after using computerized… ehmm….board game…ah…in the classroom…(CBG G16P3)	Motivational Management
I like to apply this kind of board game, which is computerized board game…so that I can explain those contents…(CBG G16P3)	Openness and Acceptance
as I was given the opportunity to list the science materials….then, I…(CBG G16P3)	Openness and Acceptance
definitely…I was given the opportunity to relate the science… ehmm…materials…through this kind of board game…(CBG G16P3)	Task Orientation
I feel motivated…ehmm…to learn more knowledge… hmm…about science after playing this board game with my friends…(CBG G16P3)	Motivational Management
as computerized board games are different with conventional teaching method…(CBG G16P3)	Openness and Acceptance
I think I can understand the learning content better... when I am applying this board game in the classroom….hmm…(CBG G23P2)	Task Orientation
I myself like to apply this computerized board game….so that I can figure out those science materials….(CBG G23P2)	Openness and Acceptance
I have to admit that after utilizing computerized board game, I have learnt a lot of science knowledge…(CBG G23P2)	Motivational Management

in my own opinion….I like to apply computerized board game….so that I can explain the contents…and then answer those…(CBG G23P2)	Openness and Acceptance
as this kind of board game can be used to…ehmm… list the science materials…(CBG G23P2)	Openness and Acceptance
through this board game, I am able to relate science material in the classroom…(CBG G23P2)	Task Orientation
Yup…I feel motivated to learn science…ehmm…after using this…(CBG G23P2)	Motivational Management
ehm…yes…absolutely….this board game is different with conventional teaching method…(CBG G23P2)	Openness and Acceptance
I understand the learning content after I apply this kind of… board game….hmm….in the classroom…(CBG G51P1)	Task Orientation
I think I like this computerized board game…as it can really…(CBG G51P1)	Openness and Acceptance
yup…after using this computerized board game…I am… really learn a lot…example…(CBG G51P1)	Motivational Management
I think I like to apply this board game…which is computerized board game…especially try to explain those science contents…(CBG G51P1)	Openness and Acceptance
ehmm…ah…computerized board game…I like to use it…(CBG G51P1)	Openness and Acceptance
I can relate the science materials…with the help of… computerized board game….mm…in the classroom…(CBG G51P1)	Task Orientation
I am really feel motivated in learning science…after this ah….computerised board game…because…(CBG G51P1)	Motivational Management
for me, this computerized board game is totally...ya… different from those conventional teaching methods…It is because…(CBG G51P1)	Openness and Acceptance

Phase Three: Generating Themes

Some Codes with Their Illustrative Data Extracts

Task Orientation: Learning Content	**Task Orientation: Science Materials**	**Motivational Management: Learning Experience**	**Motivational Management: Personal Feeling**
I think …I can understand…the	*emm..I do relate the science*	*board games is really helping me*	*I feel more motivated…to learn*

content when I apply this…board games..(PBBG G27P2)	*materials….emm with this… board games…(PBBG G27P2)*	*out to learn… a lot…(PBBG G27P2)*	*science topic… once I apply this board games…(PBBG G27P2)*
…I can understand the science content…ah-ha… when I learn them with the help of…this board games if really…(PBBG G10P3)	*emm…I can relate those science materials…hmm…with this… board game…(PBBG G10P3)*	*It is really helpful…emm…for me…For example, I can master hmm…(PBBG G10P3)*	*yup…I feel much motivated after playing… emm…this board game in learning science…(PBBG G10P3)*
I am really understand…emm…the learning content… once I am exposed to Paper-Based Board Game…(PBBG G33P1)	*I can relate those science materials with the… hmm… help of this board game so that…(PBBG G33P1)*	*ehmm….I think I have learnt a lot…after using this… hmm….board game in the classroom…(PBBG G33P1)*	*I always…emm….feel… motivated…to learn the science topics…(PBBG G33P1)*
…I think I can understand the… ah..content easily…(PBBG G50P1)	*I can relate this board game…ehmm…with the science materials…(PBBG G50P1)*	*I think that I can learn a lot of science concepts…hmm…after playing this kind of board game…(PBBG G50P1)*	*…ehmm…feel motivated to learn those…ah…science topics….especially when I was exposed to…this board game…(PBBG G50P1)*
I think with this board game…ehmm…I can know… ah…more about the learning content in science topics…(PBBG G40P3)	*Yup…I can relate the science materials….ah..ha …in the classroom… after applying Paper-Based Board Game…(PBBG G40P3)*	*I learn a lot after utilizing this kind of board game….as I have gained the knowledge (PBBG G40P3)*	*In my opinion…I feel motivated to learn science while I am playing this board game…with my friends…(PBBG G40P3)*
can understand…ehmm…those contents when I am… trying to apply this computerized board game, especially when it… (CBG G32P1)	*ehmm…this version of board games….I can relate the science materials better…(CBG G32P1)*	*after using this kind of board game…ehmm… I learn a lot about science topics…ah…in the class…For instance…(CBG G32P1)*	*Ah…ha….yes..I feel motivated a lot when I try to learn science... after using this Computerized Board Games. (CBG G32P1)*

I think that I can understand…hmm…the learning content of science….after applying the computerized board game…(CBG G44P4)	*I can relate science materials after applying this kind of board game…(CBG G44P4)*	*I do learn a lot of science content… once we have used this… emm… board game…(CBG G44P4)*	*I have a lot of motivation… after I was given the chance to apply computerized board game with my friends…(CBG G44P4)*
I can say that I do understand…hmm…the science contents while I am applying this board game…(CBG G16P3)	*definitely…I was given the opportunity to relate the science... emm...materials… through this kind of board game…(CBG G16P3)*	*teacher….I am really learning a lot after using computerized… ehmm….board game…ah…in the classroom…(CBG G16P3)*	*I feel motivated…ehmm …to learn more knowledge… hmm…about science after playing this board game with my friends…(CBG G16P3)*
I think I can understand the learning content better... when I am applying this board game in the classroom…. hmm…(CBG G23P2)	*through this board game, I am able to relate science material in the classroom…(CBG G23P2)*	*I have to admit that after utilizing computerized board game, I have learnt a lot of science knowledge…(CBG G23P2)*	*Yup…I feel motivated to learn science…ehmm…after using this…(CBG G23P2)*
I understand the learning content after I apply this kind of... board game….hmm….in the classroom…(CBG G51P1)	*relate the science materials…with the help of... computerized board game…. mm…in class… (CBG G51P1)*	*yup…after using this computerized board game…I am… really learn a lot…example…(CBG G51P1)*	*I am really feel motivated in learning science…after this ah…. computerised board game… (CBG G51P1)*

Openness and Acceptance: Perception	**Openness and Acceptance: Application**	**Openness and Aceptance: Classification**
I like this board games… as it really can help me to… learn and figure out… emm…what the science material is about…(PBBG G27P2)	*I prefer…emm…to use this board games…ah-ha… explain the contents, hmm… especially when I try to answer questions. (PBBG G27P2)*	*I do like… to use this board game to…hmm… list the… science materials…(PBBG G27P2)*
yes…it is totally different with those…emm…conventional… teaching method…(PBBG G27P2)	*emm…I like to use Paper-Based Board Games…hm… to explain the contents to my group*	*use Paper-Based Board Games to list science materials. Em.. (PBBG G10P3)*

	members or answering questions…(PBBG G10P3)	
I do like this board game…one of the reasons is to em… figure out what the science material…(PBBG G10P3)	*Yes, I do like to use Paper-Based Board Game in the classroom…as I can…ehmm…(PBBG G33P1)*	*I like to use this version of board game…emm…so that…I can… list those science materials…(PBBG G33P1)*
this kind of board games… emm…is… different with conventional teaching method…hmm..in the classroom...(PBBG G10P3)	*I like to use…hmm…Paper-Based Board Games….since it can help me…ah…to explain those learning contents…(PBBG G50P1)*	*ehmm….I also prefer to use this board game….hmm… to list those science materials….(PBBG G50P1)*
I do like this kind of board game…as it really helps me to… hmm…(PBBG G33P1)	*I like to apply this version of board game…as I am able to…hmm….to explain the learning contents in science textbook…(PBBG G40P3)*	*ah…ha…I am really like to use….this board game to… ehmm… to list out the science materials…(PBBG G40P3)*
in my opinion…Paper-Based Board Games are totally different… hmmm…from those conventional teaching methods, including…em…(PBBG G33P1)	*I like to apply this board game in the classroom…I am also use it and able to…hmm…explain the science contents…(CBG G32P1)*	*I am quite prefer to use…computerized board games to do some works, such as…hmm…listing out the science… materials….(CBG G32P1)*
I do like this kind of board games…as it can help me… hmm…to figure out those science materials…(PBBG G50P1)	*I myself…ehmm…like to use computerized board games…especially when I am…trying to explain the contents…or…(CBG G44P4)*	*I like to use or apply…hmm…computerized board game…so... I am able to list science materials…(CBG G44P4)*
absolutely, this board games are…ehmm…different from conventional teaching method in the…ehmm…science class…(PBBG G50P1)	*I like to apply this kind of board game, which is computerized board game…so that I can explain those contents…(CBG G16P3)*	*as I was given the opportunity to list the science materials….then, I…(CBG G16P3)*
through this board game too…hmm…I also would like to say that…ehmm…it can help me to figure out those science materials….(PBBG G40P3)	*in my own opinion….I like to apply computerized board game….so that I can explain the contents…and then answer those…(CBG G23P2)*	*as this kind of board game can be used to…ehmm… list the science materials…(CBG G23P2)*

Yup…this kind of board game….is totally different with…ehmm…. the conventional teaching method before…(PBBG G40P3)	*I think I like to apply this board game…which is computerized board game…especially try to explain those science contents…(CBG G51P1)*	*ehmm…ah…computerized board game…I like to use it…(CBG G51P1)*
I do like this…ehmm… computerized board game…, as it can help me to figure out those science materials…(CBG G32P1)		
For me, this board game is different from those conventional… ehmm…teaching method…(CBG G32P1)		
I like computerized board game…especially to help me in figuring out what the science materials…(CBG G44P4)		
yes…this kind of board games is different from ehm... conventional teaching method…(CBG G44P4)		
for me, I like to play this computerized board game…so that… it can assist me to…ehmm…(CBG G16P3)		
as computerized board games are different with conventional teaching method…(CBG G16P3)		
I myself like to apply this computerized board game….so that I can figure out those science materials….(CBG G23P2)		
ehm…yes…absolutely….this board game is different with conventional teaching method…(CBG G23P2)		
I think I like this computerized board game…as it can really…(CBG G51P1)		

for me, this computerized board game is totally...ya… different from those conventional teaching methods…It is because…(CBG G51P1)	