



Faculty of Cognitive Sciences and Human Development

**COMPUTATIONAL THINKING THROUGH UNPLUGGED
PROGRAMMING ACTIVITIES :
EXPLORING STUDENTS' LEARNING EXPERIENCES**

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The dissertation entitled **Computational Thinking Through Unplugged Programming Activities: Exploring Students' Learning Experiences** was prepared by Lim Bih Loong and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfilment of the requirements for the degree of Master of Science (Learning Sciences).

It is hereby confirmed that the student has done all the necessary
amendments for examination and acceptance.

(PROF. DR. CHEN CHWEN JEN)

Date: _____

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Author

[LIM BIH LOONG]

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LIST OF ABBREVIATIONS

CT	Computational Thinking
UPA	Unplugged Programming Activities
PK	Pemikiran Komputasional
APU	Aktiviti Pengaturcaraan Secara Unplugged

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ABSTRACT

COMPUTATIONAL THINKING THROUGH UNPLUGGED PROGRAMMING ACTIVITIES: EXPLORING STUDENTS' LEARNING EXPERIENCES

In the recent year, Computational Thinking (CT) has gained much attention in educational research and practice. CT skills can be taught via computing activities that involve different types of programming tasks or via Unplugged Programming Activities (UPA) that do not involve the use of digital devices to represent and deliver programming concepts. UPA is an appropriate teaching approach for schools that do not have sufficient technological infrastructure. Studies have shown the effectiveness of UPA in developing CT skills and is comparable to the technology driven learning method. The aim of this research study is to explore the experience of primary school students' on learning algorithm (one of the CT skills) through UPA. A total of thirty-one participants took the pre-test, followed by exposure to the UPA learning material and post-test in this study. Based on their pre-test and post-test results, nine of them were selected for individual interview. The result shows that there is no significant effect of the learning material in increasing the participants' algorithm skill. However, the mean for post-test score is slightly higher than the mean for pre-test score. From the responses gathered through the interview sessions, four theme which are Good Learning Quality, Much Knowledge, Easy and Useful have been derived.

Keywords : Computational Thinking, Unplugged Programming Activities, Algorithms

ABSTRAK

PEMIKIRAN KOMPUTATIONAL MELALUI AKTIVITI PENGATURCARAAN SECARA UNPLUGGED: MENEROKA PENGALAMAN PEMBELAJARAN PELAJAR

Dalam beberapa tahun kebelakangan ini, Pemikiran Komputasional (PK) telah mendapat perhatian dalam amalan dan penyelidikan pendidikan. Kemahiran PK boleh diajar melalui aktiviti pengaturcaraan yang melibatkan penggunaan komputer atau melalui Aktiviti Pengaturcaraan Secara Unplugged (APU) yang tidak melibatkan penggunaan peranti digital dalam mewakili dan memahami konsep pengaturcaraan. APU adalah pendekatan mengajar yang sesuai untuk sekolah-sekolah yang tidak mempunyai infrastruktur teknologi yang mencukupi. Keberkesanan APU dalam membangunkan kemahiran PK adalah sama seperti menggunakan teknologi. Tujuan penyelidikan ini adalah untuk meneroka pengalaman pembelajaran pelajar sekolah rendah terhadap kemahiran algoritma (salah satu kemahiran PK) melalui APU. Seramai tiga puluh satu orang peserta mengambil ujian pra, diikuti dengan pendedahan kepada bahan pembelajaran dan ujian pasca dalam kajian ini. Berdasarkan keputusan ujian pra dan ujian pasca, sembilan daripada mereka dipilih untuk sesi temu duga. Keputusan menunjukkan bahan pembelajaran APU tidak mempunyai kesan signifikan dalam meningkatkan kemahiran algoritma peserta. Walau bagaimanapun, purata bagi skor ujian pasca adalah lebih tinggi daripada purata skor ujian pra. Daripada maklum balas yang dikumpulkan melalui temuduga, empat tema telah diperolehi - Kualiti Pembelajaran Baik, Banyak Menimba Pengetahuan, Mudah dan Berguna.

Kata kunci : *Pemikiran Komputasional, Aktiviti Pengaturcaraan Secara Unplugged, Algoritma*

INTRODUCTION

The term Computational Thinking (CT) was first introduced in 2006 (Selby, 2013). CT skills refer to a collection of mental tools that enables an individual to solve problems more effectively by imitating a computer scientist's way of thinking (Wing, 2006). It is an approach for solving problems, designing systems and comprehending human behaviour that draws on the fundamental concepts of programming (Wing, 2006). Over the past decade, CT has gained much attention in educational research and practice (Wright, Rich, & Leatham, 2012; Shute, Sun & Asbell-Clarke, 2017). Many researchers suggest that CT skills relates to coding or programming (Wing, 2010; Wright, Rich, & Leatham, 2012; Shute, Sun & Asbell-Clarke, 2017). However, according to National Research Council (2012), CT skills should not only be acquired by the programmers but everyone.

Today, CT is considered as one of the skills that must be taught, learnt and mastered by the young generation (Weintrop, Orton, Horn, Beheshti, Trouille, Jona & Wilensky, 2014). Mastering the skills will provide the young generation with greater opportunities to build up their competitiveness in the fast-paced digital economy (Bocconi, Chioccariello, Dettori, Ferrari & Engelhardt, 2016; Weintrop *et al.*, 2014). CT skills have been integrated into the education systems across the world and Malaysia is the first country in South East Asia region that incorporates CT skills into its national curriculum (Abas, 2016).

CT skills are often taught via computing activities that involve different types of programming tasks (Brackmann, Román-González, Robles, Moreno-León, Casali & Barone, 2017). However, another approach to teach CT skills is via Unplugged Programming Activities (UPA). UPA is defined as activities that do not involve the use of digital devices, instead logic games, cards, strings or physical movements are used to represent and understand programming concepts (Kalelioglu, Gülbahar & Kukul, 2016). UPA is an appropriate teaching approach for a huge number of schools that do not have sufficient technological infrastructure such as electricity, Internet, computers, mobile devices, and other electronic devices (Amrita, Muir & Rao, 2016).

The limited access to technological devices and facilities such as computers, tablets, educational robotics and others devices is a global issue (Sadatul, 2017). Countries in Africa, Asia and even many parts of European continent still left behind with regards to the implementation of technological-based teaching and learning approach (Wallet, 2014). Similar situation is found in Malaysia where the use of technology in education is still at the level that cannot be proud of. Fifty percent (50%) of teachers use their own computers for teaching and learning purposes in five areas of Selangor and 35% of school do not have appropriate computer laboratories and servers (Samuel & Zaiton, 2007). Therefore, UPA can be a great approach to teach CT skills in schools. The aim of this research study is to explore the experience of primary school students' learning about algorithm (one of the CT skills) through UPA.

Six Distinctive Aspects of CT Skills

According to Shute, Sun and Asbell-Clarke (2017), CT skills consists of six aspects;

- (a) Abstraction – identify the important parts of a problem or situation by eliminating the irrelevant parts of a problem. Abstraction is the most distinctive aspect of CT (Wing, 2008).
- (b) Decomposition - breaking a problem down into the smaller parts.
- (c) Algorithms - identifying steps in solving a problem.
- (d) Evaluation - finding the most efficient solution to a problem.
- (e) Generalization or pattern recognition - applying previous solution or approach to solve a problem.
- (f) Automation - using the information-processing agent as solution to a problem.

Effects of CT Skills on Learning

The goal of learning CT is to improve knowledge on some fundamental elements of Computer Science and support problem solving computational concepts (Wing, 2006). The integration of CT skills in teaching and learning has brought positive impacts to students' academic achievement as well as their motivation to learn (Mironova, Amitan & Vilipõld, 2012; Weintrop, 2016; Gardeli & Vosinakis, 2017). After learning CT skills, students especially from the weak group are able to perform better in their examination result in several subjects, particularly for Science and Mathematics subjects thus reducing the gap between them and the advance group (Mironova *et al.*, 2012). Having CT skills also helps a learner to deepen the learning of the contents, especially for STEM subjects (Repenning, Webb, & Ioannidou, 2010).

Developing CT Skills Through UPA

Brackmann *et al.* (2017) report a significant increment of CT skills among students after being exposed to UPA in their teaching and learning sessions. The effectiveness of UPA in developing CT skills is as effective as using technology driven systems or gadgets and it is a

valuable alternative for introducing programming to students (Brackmann *et al.*, 2017; Faber, Wierdsma, Doornbos, Van Der Ven, & De Vette, 2017). The use of UPA in developing CT skills also have positive effects to students' motivation (Faber *et al.*, 2017; Gardeli & Vosinakis, 2017).

Algorithm

Algorithm is one the distinctive aspects of CT (Shute, Sun & Asbell-Clarke, 2017; Wing, 2006). Erickson (2019) defines algorithm as “an explicit, precise, unambiguous, mechanically-executable sequence of elementary instructions, usually intended to accomplish a specific purpose”. Various problems can be solved by algorithms (Sharma & Khurana, 2013). For example: How to plan a tour visiting several towns in the cheapest possible order? How to share information as well as keep secrets? Algorithms are useful for solving routine questions or exercises in which the algorithms can be constructed from prior experience (Bodner, 1987).

Increasing scholarly attention has been given to the perception of algorithms (Musiani, 2013). This suggests that people form diverse mental models about how algorithms operate (Lee, 2018). As algorithms have been introduced to Malaysia education syllabus through the subject “*Teknologi Maklumat dan Komunikasi (TMK)*”, it raises the question on how primary school students perceive algorithms? The studies about algorithm together with other CT skills have been carried out in many western countries, particularly in European countries. However, studies on CT skills that are carried out in Asia region are rather minimal. In Malaysia, studies on CT skills mostly focus on activities that use technological devices (Anna, Sabariah, Wong & Muralindran, 2017; Anna & Sabariah, 2014).

METHODOLOGY

Research Design

The study employed a mixed method where both quantitative and qualitative methods were used to gather data for the purpose of this study. The mixed method approach enables researchers to explore a subject in greater depth (Lund Research, 2012).

Learning Material

The learning material on algorithm that was designed for this study consisted of two parts. The first part is the grid for ‘Steps to Make Fruit Salad’ which was adapted from CS Unplugged (n.d.). For this part, as shown in Figure 1, students were required to draw arrows to complete the grid.

The second part requires students to list out all the steps to make fruit salad. This part, as shown in Figure 2, was adapted from “*Teknologi Maklumat dan Komunikasi*” Year 6 textbook of the Malaysian syllabus and study by Brackmann *et al.* (2017).

STEPS TO MAKE FRUIT SALAD (ENGLISH VERSION)			
			
			
			

Figure 1 First Part of the Learning Material - Grid for ‘Steps to Make Fruit Salad’
(Planning of steps)

**List the steps to make fruit salad
(English version)**

1. Wash the apples till clean.

2.
.....

3.
.....

4.
.....

5.
.....

Figure 2 Second Part of the Learning Material - List the Steps to Make Fruit Salad
(Giving step-by-step instruction)

Instruments

Two instruments were developed for the purpose of this study;

1. A pre-test and post-test experimental design was used to assess students' learning of CT skills. Students took the pre-test before experiencing the learning material and took the post-test after going through the learning material.

The test consists of two section: Section A and Section B. Section A consists of five multiple-choice questions while Section B consists of three structured questions. The test was adapted from Year 6 "*Teknologi Maklumat dan Komunikasi (TMK)*" textbook.

2. Structured interview questions were used to further explore students' perceived learning. The interview questions were adapted from Keong (2017).

Students with the perfect scores in the post-test, those scored more than 20 marks increment in their post-test compared with their pre-test and those who scored more than 15 marks decrement in their post-test compared with their pre-test were selected for the interview sessions.

Data Collection Procedures

The Malaysia Ministry of Education, Sarawak State Education Department and the authority of the school involved in this study had granted permission for this study to be carried out. The participants together with their parents were briefed on the purpose of the study. The participants and their parents were also informed about the audiotaping during the interview sessions. Parents of all participants had given their consent by signing the consent form witnessed by the headmistress of the school. Data collection through pre-test, post-test and

interview session were conducted after school. The interview was carried out using '*Bahasa Malaysia*'.

Participants

Thirty-one respondents from one primary public schools in Simunjan, Sarawak took part in this study. All the respondents were students of higher primary. From the thirty-one respondents who had took part in pre-test and post-test, only nine were selected for structured interview session.

The selection of the respondents for interview session were based on their performances during the pre-test and post-test. Four respondents scored 100% mark in their post-test. Three respondents showed increment of more than 20% in their post-test compare to their pre-test. Two respondents showed decrement of more than 15% in their post-test compare to their pre-test.

Data Analysis

Quantitative Method

Data gathered from the pre-test and post-test were analysed using SPSS software. Paired T-Test was carried out to test whether there is a significance difference between the pre-test and post-test.

Qualitative Method

For the structured interview, the data gathered was qualitatively analysed to identify the emerging themes. The interview transcript was read through and divided into favourable and unfavourable participants' responses. Through prompts and follow-up questions, the descriptions and justifications to the participants' favourable and unfavourable responses were

gathered. The participants' significant responses toward the interview questions on perceived learning were coded. The appropriate themes were then derived from the compiled coded responses. Figure 3 shows the steps taken to derive the themes.

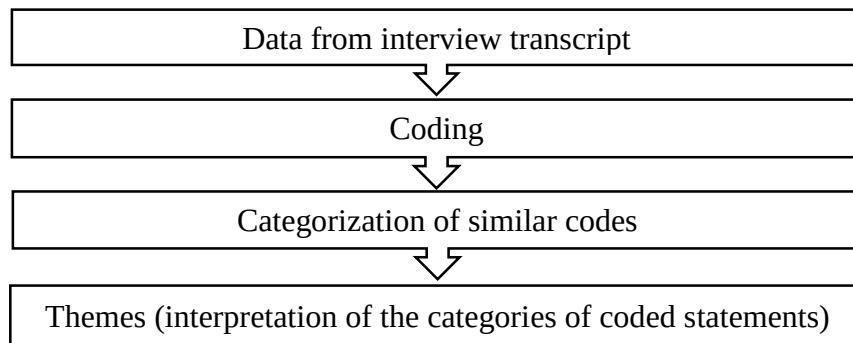


Figure 3 Steps to Derive the Themes

RESULTS & DISCUSSION

Quantitative Study

This study involved 20 male participants and 11 female participants with their age ranging from 10 to 12 years old.

Paired T-Test

As shown in Table 1, there is no significant effect of the learning material in increasing the participants' algorithm skills ($p > .05$, $p = .259$) although the mean for post-test score (66.9%) is slightly higher than the mean for pre-test score (64.3%) as shown in Table 2.

Table 1

Paired Samples Test

		Paired Differences							
		95% Confidence Interval of the Difference							
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	PreTest - PostTest	-2.64516	12.80247	2.29939	-7.34115	2.05082	-1.150	30	.259

Table 2

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest	64.2903	31	19.75381	3.54789
	PostTest	66.9355	31	20.84696	3.74422

The result of Paired T-Test is probably due to the frequency of the exposure to the learning material where all the participants had only been exposed one time to the learning material. Higher frequency of exposure may facilitate the participants' learning (Effiong, Oji & Igiri, 2015). It may also assist participants in producing better score for the post-test.

Qualitative Study

A total of nine participants were selected for structured interview based on their pre-test and post-test result. Table 3 displays the matrix of the selected participants' demographic background.

Table 3

Matrix of the participants' demographic background

Participants	Age	Gender	Race	Pre-Test Score	Post-Test Score	Difference in score
P1	10	Female	Malay	82	65	-17
P2	10	Male	Malay	59	100	+41
P3	10	Male	Malay	29	59	+30
P4	10	Female	Malay	59	82	+23
P5	11	Female	Malay	94	100	+6
P6	11	Male	Malay	59	82	+23
P7	12	Female	Malay	82	59	-23
P8	12	Male	Bugis	100	100	0
P9	12	Male	Malay	100	100	0

Table 4 displays the response of the selected nine participants towards the algorithm in terms of their perceived learning. The data gathered from the interview is divided into two main categories which are favourable and unfavourable response.

Table 4

Perceived learning of the selected participants on algorithm

Themes	Favourable response (%)				Unfavourable response (%)			
	Good learning quality	Much knowledge gained	Easy	Useful	Poor learning quality	Little knowledge gained	Difficult	Not useful
Participants	8 (89%)	8 (89%)	8 (89%)	8 (89%)	1 (11%)	1 (11%)	1 (11%)	1 (11%)

Theme 1: Good Learning Quality

There are two interview questions related to participants' learning quality. The questions were;

- Question 1(i) : What do think of your learning about planning of steps when doing the activity?
- Question 1(ii) : What do think of your learning about giving step-by-step instruction when doing the activity?''.

The result shows that a total of eight participants (89%) expressed that they had good learning quality while one participant (11%) expressed that she had a poor learning quality throughout the activity planning of steps (Question 1(i)).

Enjoy

Five participants (P1, P5, P6, P7, P8) commented that they enjoyed the activity planning of steps mainly due to the attractive presentation of learning material that manage to attract their attention and arouse their motivation to learn.

Fun

Three participants (P2, P3, P4) stated that the activity was fun. From the comments received, they felt the activity was fun because they were learning with their peers.

Table 5 shows the individual feedback from each participants on the planning of steps activity.

Table 5

Participants' responses on the planning of steps activity

Participant	Response
P1	The activity seems interesting. I want to try it out when I see it. <i>Aktiviti nampak menarik. Saya hendak mencubanya bila lihat.</i>
P2	It is fun. I am happy because can do it with my friends. <i>Menyeronokkan. Saya gembira sebab boleh buat bersama dengan kawan.</i>
P3	Fun and best. Because I do it in group. <i>Seronok dan best. Sebab saya buat dalam kumpulan.</i>
P4	Yes. It is fun. I learn something new. The movement, counting steps. <i>Ya. Ianya menyeronokkan. Saya belajar sesuatu yang baru. Pergerakan, mengira langkah.</i>
P5	I enjoy doing the activity. The pictures are pretty and interesting. <i>Saya enjoy buat aktiviti itu. Gambar-gambarnya cantik dan menarik.</i>
P6	I like it. I like to draw the arrows on the map (refer to grid). <i>Saya suka. Saya suka melukis anak panah dalam peta.</i>
P7	I do not like the activity. <i>Saya tak suka aktiviti itu.</i>
P8	Best! I enjoy doing the activity. <i>Best! Saya suka buat aktiviti itu.</i>
P9	I really like the activity. Because it is easy to do and the pictures are beautiful. <i>Saya sangat suka aktiviti itu. Sebab ianya senang dibuat dan gambar-gambarnya cantik.</i>

For question 1(ii), eight participants (89%) expressed that they had good learning quality throughout the giving step-by-step instruction activity compared to only one participant (11%) who expressed that she had poor learning quality.

Fun

Four participants (P2, P3, P5, P6) stated that the giving step-by-step instruction activity were fun and they really liked the activity. From the comments received, it can be observed that the main reason which contributed to their good learning quality was the level of the activity which was easy to be completed by them.

Learn new knowledge

Four participants (P1, P4, P8, P9) commented that they learn new knowledge while doing the activity. P1 and P4 stated that it was their first time doing the activity.

Table 6 shows the individual feedbacks from each participants on giving step-by-step instruction activity.

Table 6

Participants' response on giving step-by-step instruction activity

Participant	Response
P1	I think it is my first time doing this activity. I gain new knowledge. <i>Saya rasa ini pertama kali saya buat aktiviti ini. Saya dapat ilmu baru.</i>
P2	Fun when doing the activity with friends. <i>Seronok bila buat aktiviti dengan kawan-kawan.</i>
P3	Fun. I can write with my own sentences <i>Seronok. Saya boleh menulis guna ayat saya sendiri.</i>
P4	I learn steps to make fruit salad. I never make fruit salad before. <i>Saya belajar langkah-langkah buat salad buah. Saya tak pernah buat salad buah sebelum ini.</i>
P5	I like doing the activity. It is easy. <i>Saya suka buat aktiviti ini. Ianya mudah.</i>
P6	I like it. Because I know how to do it. <i>Saya suka. Sebab saya tahu macam mana nak buat.</i>
P7	The activity is a bit boring. I don't like it. <i>Aktiviti agak membosankan. Saya tak suka.</i>
P8	The activity is so interesting. I am having fun doing it. <i>Aktiviti itu sungguh menarik. Saya berasa seronok bila buatnya.</i>

P9 I understand very well how to do the activity by myself without assistance.
Saya sangat faham macam nak buat aktiviti sendiri itu tanpa bantuan.

Theme 2: Much Knowledge Gained

There are two interview questions related to the knowledge gained by the participants in this study. The questions were;

- Question 2(i) : When you are doing the planning of steps activity, what knowledge have you gained?
- Question 2(ii) : When you are giving step-by-step instruction, what knowledge have you gained?

Eight participants (89%) stated that they gained much knowledge from the planning of steps activity while one participant (11%) expressed that she gained little knowledge (Question 2(i)).

Problem solving: Finding the best path

Five participants (P1, P4, P5, P8, P9) commented that they had learnt finding the best path. From the participants' comments, it can be concluded that they manage to learn algorithm skill. Finding the best path is considered a good routing algorithm skill (Sharma & Khurana, 2013).

Problem solving: More than one way to solve a problem

Two participants (P3, P6) stated that they had learnt that there is more than one way to solve a problem.

Table 7 shows the individual feedbacks from each participants on the knowledge they gained from doing the planning of steps activity.

Table 7

Participants' response on knowledge gained while doing the planning of steps activity

Participant	Response
P1	Finding the best path to make fruit salad. <i>Mencari jalan terbaik untuk buat salad buah.</i>
P2	Steps in how to make fruit salad. <i>Cara-cara bagaimana nak buat salad buah.</i>
P3	There is more than one way to solve problem. <i>Ada lebih dari satu cara untuk selesaikan masalah.</i>
P4	Find the best path on how to make fruit salad. <i>Cari jalan terbaik untuk buat salad buah.</i>
P5	Find the best path on how to make fruit salad. <i>Cari laluan terbaik untuk buat salad buah</i>
P6	There is more than one way to solve problem. <i>Terdapat lebih daripada satu cara untuk selesaikan masalah.</i>
P7	I don't know. <i>Saya tak tahu.</i>
P8	Finding the best path to produce fruit salad. <i>Mencari laluan terbaik untuk menghasilkan salad buah.</i>
P9	Finding the best path to make fruit salad. <i>Mencari laluan terbaik untuk membuat salad buah.</i>

Similar to question 2(i), eight participants stated that they gained much knowledge from the giving step-by-step instruction activity compared to only one participants expressed that she gained little knowledge. Most of the participants took longer time before they could answer these two questions.

Correct and accurate steps

Seven participants (P1, P2, P3, P4, P5, P6, P8) commented that they had learnt the correct and accurate steps to make fruit salad from doing the giving step-by-step instruction activity.

Systematic

Participant 9 (P9) was the only participant who stated that he learned systematic way to solve problem.

Table 8 shows the individual feedbacks from each participants on the knowledge they gained from doing the activity giving step-by-step instruction.

Table 8

Participants' response on knowledge gained while doing the giving step-by-step instruction activity

Participant	Response
P1	The correct and accurate steps to make fruit salad. <i>Langkah-langkah yang betul dan tepat untuk buat salad buah.</i>
P2	The correct and accurate steps to make fruit salad. I also learn how to take care of cleanliness when make fruit salad. <i>Langkah-langkah yang betul dan tepat untuk membuat salad buah. Saya juga belajar bagaimana menjaga kebersihan apabila membuat salad buah.</i>
P3	The correct and accurate steps to make fruit salad. <i>Langkah-langkah yang betul dan tepat untuk membuat salad buah.</i>
P4	The correct and accurate steps to make fruit salad. <i>Langkah yang betul dan tepat untuk buat salad buah.</i>
P5	The correct and accurate steps to make fruit salad. <i>Langkah-langkah yang betul dan tepat untuk buat salad buah.</i>
P6	The correct and accurate steps to make fruit salad. <i>Langkah-langkah yang betul dan bertepatan untuk buat salad buah.</i>
P7	<i>(The participant didn't give her answer)</i>
P8	The correct and accurate steps to make fruit salad. <i>Langkah-langkah yang betul dan tepat untuk menghasilkan salad buah.</i>
P9	Systematic way to make fruit salad. <i>Cara yang sistematik untuk membuat salad buah.</i>

Theme 3: Easy

Two questions related to the difficulty of the activity were;

Question 3(i) : Do you find the planning of steps is easy or difficult? Why?

Question 3(ii) : Do you find the giving step-by-step instruction is easy or difficult? Why?

Eight participants (P1, P2, P3, P4, P5, P6, P8, P9) stated that the planning of steps activity was easy.

Easy to understand

Four participants (P1, P3, P4, P6) commented that the activity was easy to understand. From the comments received, the activity is a bit too simple for their level. It is recommended to have more diverse set of algorithm learning materials with different difficulty levels to facilitate the learning. According to Faber *et al.* (2017), students became much engaged and motivated with the much difficult unplugged activity.

Sufficient time

Four participants (P2, P5, P8, P9) commented they were able to complete the activity within the given time. This supports that varied set of activities with different levels of difficulty are needed to observe the effectiveness and at the same time facilitate the learning process (Faber *et al.*, 2017)

Table 9 displays the participants' response on the difficulty level of the planning of steps activity.

Table 9

Participants' responses on the difficulty of the planning of steps activity.

Participant	Response
P1	Easy. The material is simple and not too much. <i>Mudah. Bahannya mudah dan tidak terlalu banyak.</i>
P2	Easy. Easy to follow and didn't take much time to complete it. <i>Mudah. Mudah untuk diikuti dan tak ambil masa yang lama untuk siapkannya.</i>
P3	Easy. Because not many paths / ways. <i>Mudah. Sebab tak banyak laluan.</i>
P4	Easy. I can easily identify the steps through the pictures. <i>Mudah. Saya boleh kenalpasti langkah-langkah melalui gambar-gambar.</i>
P5	Easy. No need to take much time. <i>Mudah. Tak ambil masa yang lama.</i>
P6	Easy. I can easily understand the pictures and the steps. <i>Mudah. Saya mudah faham gambar-gambar dan langkah-langkah.</i>
P7	Difficult. I do not understand the material. <i>Susah. Saya tidak faham bahan itu.</i>
P8	Easy. I can complete the activity in the short time. Because it is easy to understand. <i>Mudah. Saya boleh habiskan aktiviti dalam masa yang pendek. Sebab ianya mudah difahami.</i>
P9	Easy. I can finish the activity within the given time. <i>Mudah. Saya boleh siapkan dalam masa yang diberikan.</i>

The same eight participants (P1, P2, P3, P4, P5, P6, P8, P9) stated that the giving step-by-step instruction activity was easy.

Easy to understand

Six participants (P1, P2, P3, P5, P8, P9) commented that the activity was simple to follow. This probably due to the suitability of the activity with participants' age. Participants with age range between 10 to 12 may need more difficult and more challenging activity. For further research in the future, it's recommended to improve the learning material by increasing the level of difficulty.

Helpful figure

Two participants (P4, P6) commented that the figure in the learning materials was very helpful. Figures such as pictures, graphs and charts are capable to facilitate the learning (Shabiralyani, Hasan, Hamad & Iqbal, 2015).

Table 10 displays the individual response from each participant about the difficulty level of the giving step-by-step instruction activity.

Table 10

Participants' responses on the difficulty of the giving step-by-step instruction activity

Participant	Response
P1	Easy. Because the steps are easy to follow. <i>Mudah. Sebab langkah-langkahnya mudah untuk diikuti.</i>
P2	Easy. Each steps are short and easy to understand. <i>Mudah. Setiap langkah-langkah pendek dan mudah difahami.</i>
P3	Easy. No need to think much. <i>Mudah. Tak perlu fikir banyak.</i>
P4	Easy because there are pictures to help me identify the steps to make fruit salad. <i>Mudah sebab ada gambar-gambar yang bantu saya kenal pasti langkah-langkah untuk buat salad buah.</i>
P5	Easy because the steps are short and easy to understand. <i>Mudah sebab langkah-langkahnya pendek dan mudah untuk faham.</i>
P6	Easy. The steps can be identified through the picture. <i>Mudah. Langkah-langkah boleh dicam melalui gambar.</i>
P7	Difficult. Because I don't understand the material. <i>Susah. Sebab saya tak faham bahan itu.</i>
P8	Easy. The steps can be easily recognized. <i>Senang. Langkah-langkahnya mudah dikenali.</i>
P9	Easy. Because there are not many step to make fruit salad. <i>Mudah. Sebab tak banyak langkah untuk buat salad buah.</i>

Theme 4: Useful

Two questions related to the usefulness of the activity were;

Question 4(i) : Do you find the planning of steps is useful? Why?

Question 4(ii) : Do you find the giving step-by-step is useful? Why?

Eight out of nine participants (89%) felt that the planning of steps activity was useful.

Applying the knowledge in daily routine

Seven participants (P1, P2, P3, P4, P5, P6, P8) stated that they could apply the knowledge they gained from the planning of steps activity in their daily routine including create a new menu. This indicates that the participants are capable to construct algorithm from their prior experience (Bodner, 1987).

Sequencing skill

Participant P9 commented that he had learn sequencing skill from the planning of steps activity.

Table 11 shows the participants' response on the usefulness of the planning of steps activity.

Table 11

Participants' responses on the usefulness of the planning of steps activity

Participant	Response
P1	Useful. I can apply this knowledge in my daily routine. <i>Berguna. Saya boleh guna ilmu ini dalam kehidupan seharian saya.</i>
P2	Useful. I can apply this knowledge during my scout camping. <i>Berguna. Saya boleh guna ilmu ini masa saya pergi perkhemahan pengakap.</i>
P3	Useful. I can learn to make other foods using this method. <i>Berguna. Saya dapat belajar untuk membuat makanan lain menggunakan kaedah ini.</i>

P4	Useful. I can learn to make other foods using this method. <i>Berguna. Saya boleh belajar membuat makanan lain menggunakan kaedah ini.</i>
P5	Useful. I can learn to make other foods using this method. <i>Berguna. Saya dapat belajar membuat makanan lain menggunakan kaedah ini.</i>
P6	Useful. I can learn to make other foods using this method. <i>Berguna. Saya dapat belajar buat makanan-makanan lain menggunakan kaedah ini.</i>
P7	Not useful. It is boring. <i>Tidak berguna. Membosankan.</i>
P8	Useful. I can learn to make other foods using this method. <i>Berguna. Saya dapat belajar untuk buat makanan lain menggunakan kaedah ini.</i>
P9	Useful. I can use this method to make sequences on other activity. <i>Berguna. Saya boleh guna kaedah ini untuk membuat turutan pada aktiviti lain.</i>

The same eight participants (89%) felt that the giving step-by-step instruction activity was useful.

Help memorizing

Seven participants (P1, P2, P3, P4, P5, P6, P9) commented that the giving step-by-step instruction activity help them in memorizing the steps on how to make fruit salad. This is contradicting with the purpose of algorithm skill itself which is to help solve various problem. The participants might be too attracted with the figures in the learning material and overlook the algorithm skill they had learnt.

Table 12 displays the participants' responses on the usefulness of the giving step-by-step instruction activity.

Table 12

Participants' thought on the usefulness of the giving step-by-step instruction activity

Participant	Response
P1	Useful. I can memorize steps to make fruit salad easily. <i>Berguna. Saya boleh mengingat langkah-langkah untuk buat salad buah dengan mudah.</i>
P2	Useful. Can remember how to make fruit salad. <i>Berguna. Boleh ingat macam mana nak buat salad buah.</i>
P3	Useful. I can remember how to make fruit salad. <i>Berguna. Saya boleh ingat bagaimana nak buat salad buah.</i>
P4	Useful. Easier to memorize steps to make fruit salad and other foods. <i>Berguna. Lebih mudah untuk hafal langkah-langkah buat salad buah dan makanan lain.</i>
P5	Useful. Help me to remember better. <i>Berguna. Membantu saya untuk ingat dengan lebih baik.</i>
P6	Useful. I can remember well. <i>Berguna. Saya boleh ingat dengan baik.</i>
P7	Not useful. It is boring. <i>Tidak berguna. Membosankan.</i>
P8	Useful. <i>Berguna</i> <i>(The participant didn't give his reason)</i>
P9	Useful. It help me memorize steps to make fruit salad. <i>Berguna. Ia membantu saya mengingat langkah-langkah buat salad buah.</i>

Unfavourable Response

Participant 7 (P7) who was shows decrement over 15 mark in her post-test gave unfavourable response during the interview session. There is possibility she felt unmotivated because she was unable to score well in her post-test and this lead to her unfavourable response.

Limitations of the Study

Location

District of Simunjan consisted of 50 primary schools. However, each school situated far away from each other. Furthermore, the school selected for this study located at the rural area. This cause the data collection from various school become difficult.

Number of Participants

The school selected for this study is from the category “*Sekolah Kurang Murid (SKM)*”. For this reason, the numbers of participants for this study was limited to thirty-one. Small numbers of participants involved in this study weakened the ability to make generalizations according to the studied population.

Recommendations

For future researchers

Future researchers can carry out similar study but need to do improvement on the instrument and expand the numbers of participants to allow generalization of the findings. Quantitative study with bigger number of participants is recommended to further study the effectiveness of UPA in developing CT skills.

Practitioners / Stakeholders

Ministry of Education, State Education Department, District Education Office, schools and teachers may use this study as a reference in establishing a proper module for UPA and CT skills development. The module can be a great reference to teachers across the nation.

Conclusion

UPA has become an appropriate alternative approach to teach CT skills especially in the area with the limited access to the technological infrastructures. The result for Paired-T test displays there is no significant effect of the learning material in increasing the participants' algorithm skill (one of the distinctive aspects of CT). This is because the participants only exposed to the learning material for one time. However, there is a slight improvement in the mean score for post-test compared to the mean score for pre-test.

From the responses gathered through the interview, four theme (Good Learning Quality, Much Knowledge, Easy and Useful) had emerged. Improvement are needed to be done on the learning material for future researchers who want to adapt this study. Larger number of participants are recommended for the quantitative study on the effectiveness of UPA in developing CT skills.

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APPENDICES

Appendix A	Consent form
Appendix B	Pre-Test & Post-Test
Appendix C	Interview Question



PARENTS' CONSENT FORM

I parents to the student name agree to allow my child to participate in a research entitled '*Computational Thinking Through Unplugged Programming Activities: Students' Learning Experiences*' conducted by Mr. Lim Bih Loong, graduates' students from the Faculty of Cognitive Science and Human Development (FCSHD) of Universiti Malaysia Sarawak (UNIMAS).

Procedures

I am aware that my child need to sit for a writing test and answer the interview questions verbally.

Risks

I am aware that there are minimal risks to my child for participating in this study. However, I am also aware that my child might feel discomfort with some of the questions in the test and interview.

Confidentiality

I am aware that all information gathered from this study are confidential and only be use for the research reporting purposes by the researchers.

Participation

I am aware that participation in this research study is voluntary. Therefore, I have the right to withdraw my child participation if I want to do so.

Inquiries

I understand that if I have further inquiries relating to this research, I may contact Mr. Lim Bih Loong at the number 013-2068919.

I had read and understand this form. My signature below states my agreement to allow my child to participate in this research as an informant.

.....

()

Date :



UJIAN PRA / UJIAN PASCA

Nama :

Kelas :

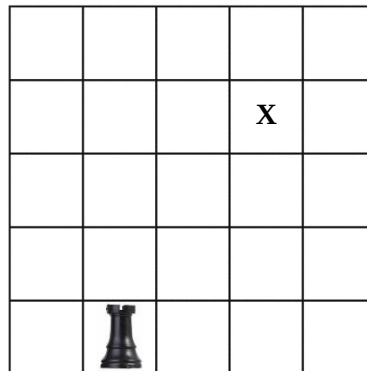
Arahan

1. Jawab semua soalan
2. Masa ujian adalah 15 minit

Markah :

BAHAGIAN A

1. Rajah 1 menunjukkan sebuah grid.

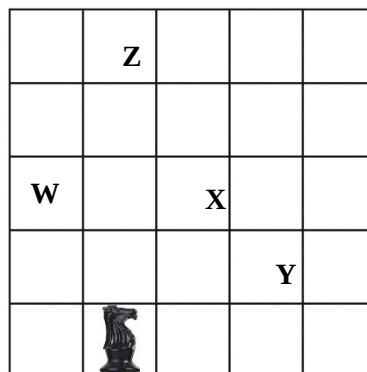


Rajah 1

Dengan hanya boleh menggerakkan buah catur ke hadapan dan kiri atau kanan, berapakah langkah minimum yang diperlukan untuk menggerakkan buah catur ke petak X?

- | | | | |
|----------|---|----------|---|
| A | 3 | B | 4 |
| C | 5 | D | 6 |

2. Rajah 2 menunjukkan sebuah papan catur.



Rajah 2

Hafiz menggerakkan buah catur pada papan catur sebanyak 2 petak ke hadapan dan 1 petak ke kiri. Di manakah kedudukan buah catur berkenaan selepas digerakkan oleh Hafiz

- | | | | |
|----------|---|----------|---|
| A | W | B | X |
| C | Y | D | Z |

3. Amin ingin meminjam buku dari perpustakaan sekolahnya. Rajah 3 di bawah menunjukkan turutan yang perlu dilakukan oleh Amin bagi membolehkannya meminjam buku dari perpustakaan sekolahnya.

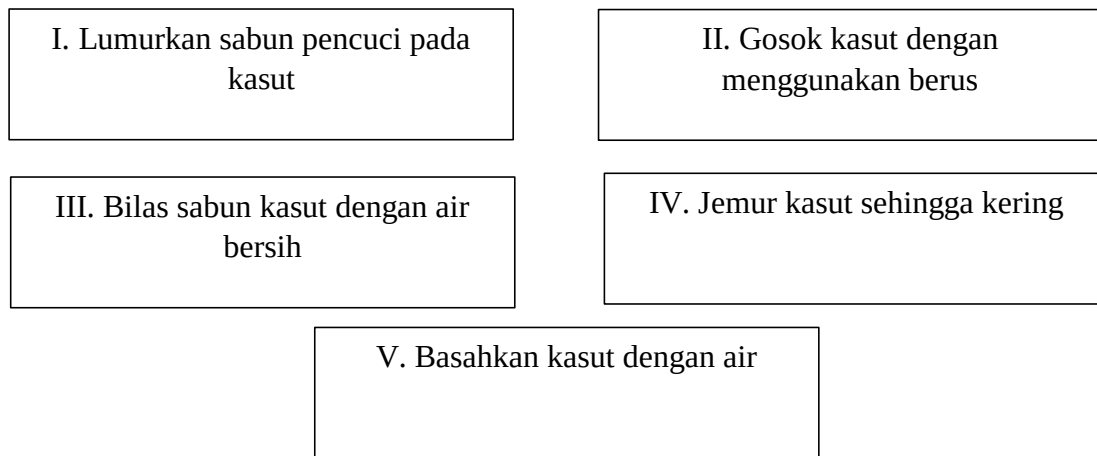
- | | |
|------|--|
| i. | Masuk ke dalam perpustakaan |
| ii. | |
| iii. | Jika buku dijumpai, pergi kaunter untuk pinjam |
| iv. | Keluar dari perpustakaan |

Rajah 3

Apakah Langkah ii?

- A** Meminta perpustakawan mencari buku yang dikehendaki
 - B** Tulis nama buku yang ingin dipinjam
 - C** Cari buku yang dikehendaki
 - D** Berbual dengan perpustakawan
4. Raju hendak membantu mencuci kereta ayahnya. Apakah langkah pertama yang harus dilakukan oleh Raju untuk mencuci kereta ayahnya?
- A** Lap kereta sehingga kering
 - B** Basuh menggunakan sabun
 - C** Bilas air sabun pada kereta
 - D** Siram kereta dengan air

5. Rajah 4 merupakan langkah-langkah untuk mencuci kasut tanpa tanpa mengikut turutan.



Rajah 4

Susun langkah-langkah tersebut agar mengikut turutan.

- A** III $\rightarrow$ I $\rightarrow$ II $\rightarrow$ V $\rightarrow$ IV
B I $\rightarrow$ IV $\rightarrow$ II $\rightarrow$ III $\rightarrow$ V
C V $\rightarrow$ IV $\rightarrow$ I $\rightarrow$ II $\rightarrow$ III
D V $\rightarrow$ I $\rightarrow$ II $\rightarrow$ III $\rightarrow$ IV

BAHAGIAN B

1. Rajah 5 menunjukkan sebuah cerek air.



Rajah 5

Nyatakan langkah-langkah untuk memasak air menggunakan cerek air pada rajah 5 mengikut turutan yang betul.

Letak cerek di atas dapur

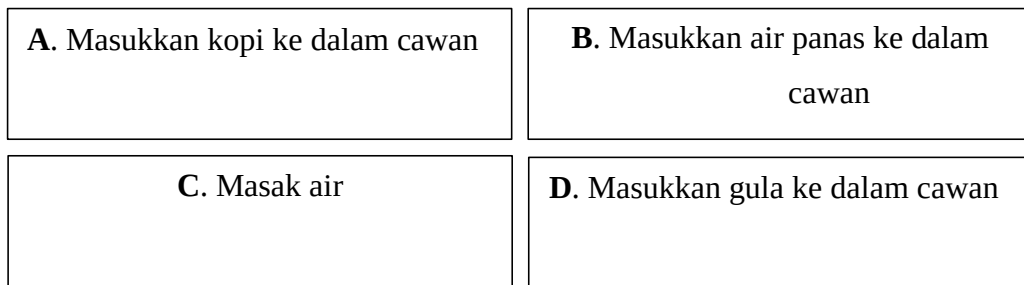
Masak air sehingga mendidih

Padamkan api setelah air mendidih

Hidupkan api

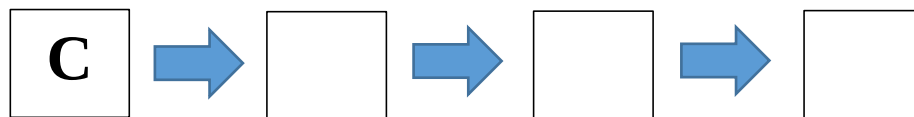
- i. Isi air ke dalam cerek
- ii.
- iii.
- iv.
- v.

2. Raju hendak membancuh secawan kopi. Rajah 6 menunjukkan langkah-langkah membancuh secawan kopi tidak mengikut turutan.



Rajah 6

Susun langkah-langkah membancuh kopi tersebut dengan betul dan mengikut turutan pada ruangan di bawah.



3. Rajah 7 menunjukkan peta kawasan kediaman Aiman.

			 Tasik Biru	
 Taman Permainan				
			 Sekolah Bandar Puteri	
	 Rumah Aiman			 Pusat Membeli-belah

Rajah 7

Jawab soalan-soalan berikut;

- (a) Berapakah langkah minimum diperlukan oleh Aiman untuk bergerak dari rumahnya ke tempat-tempat berikut?
- (i) Sekolah Bandar Puteri petak
- (ii) Taman permainan petak

- (b) Tempat manakah memerlukan paling sedikit langkah dari rumah Aiman?

.....

- (c) Tempat manakah memerlukan paling banyak langkah dari rumah Aiman?

.....

- (d) Aiman belajar di Sekolah Bandar Puteri. Aiman hendak pergi ke taman permainan selepas waktu persekolahan. Berapa langkah minimum diperlukan Aiman untuk pergi ke taman permainan dari sekolahnya?

.....



KML6066

RESEARCH PAPER IN LEARNING SCIENCES

Computational Thinking Through Unplugged Programming Activities:
Exploring Students' Learning Experiences

DATA OF INFORMANT

Informants

Gender : Male / Female

Class :

Race :

Religion :

Address :

.....

No. of siblings :

INTERVIEW QUESTIONS (ENGLISH)

1. (i) What do think of your learning about planning of steps when doing the activity?

.....

- (ii) What do think of your learning about giving step-by-step instruction when doing the activity?

.....

2. (i) When you are doing the planning of steps activity, what knowledge have you gained?
 [Hint: more than one way to solve a problem, trying to find the best way, etc]

.....

- (ii) When you are giving step-by-step instruction, what knowledge have you gained?
 [Hint: being systematic, accurate, etc]

.....

3. (i) Do you find the planning of steps is easy or difficult? Why?

.....

- (ii) Do you find the giving step-by-step instruction is easy or difficult? Why?

.....

4. (i) Do you find the planning of steps is useful? Why?

.....
.....

(ii) Do you find the giving step-by-step is useful? Why?

.....
.....