

Faculty of Cognitive Sciences and Human Development

The Development of the STEM ICT Teaching Inventory (SITI) Instrument to Measure ICT Integration in STEM teaching among TVETMARA Educators

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The Development of the STEM ICT Teaching Inventory (SITI) Instrument to Measure ICT Integration in STEM Teaching among TVETMARA Educators

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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

STEM education has garnered significant global attention due to its critical role in preparing students for future employment in an increasingly technological world. Recognizing this importance, Malaysia has made STEM education a national priority, focusing on integrating Information and Communication Technology (ICT) into STEM teaching. This study aims to develop and validate the STEM ICT Teaching Inventory (SITI), an instrument designed to assess ICT integration in STEM teaching among educators at TVETMARA, a private Malaysian Technical and Vocational Education and Training (TVET) provider. The study is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework and addresses contextual factors affecting ICT integration in STEM education. The development of SITI employed an exploratory sequential mixed-method approach (QUAL→quan) using three phases of instrument development. The first phase involved a qualitative study exploring ICT integration in STEM teaching through semi-structured interviews with 10 TVETMARA educators, complemented by classroom observations and lesson plan analysis. Thematic analysis using Quirkos software identified five key themes: ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practices, and Lesson Preparation. These themes informed the development of the SITI instrument, resulting in an initial pool of five constructs with 42 items in the second phase. The third phase of SITI development involved a quantitative study to validate SITI's content and construct validity. Expert validation and descriptive analyses retained five constructs and 42 items. For construct validation, the SITI instrument was administered to TVETMARA educators in two stages: exploratory (n = 162) and confirmatory (n = 265). Exploratory Factor Analysis (EFA) using IBM SPSS 22 reduced the instrument to 32 items across five constructs, although the Lesson Preparation

construct was excluded due to inter-factor correlations. Confirmatory Factor Analysis (CFA) using IBM SPSS Amos 26 established convergent and discriminant validity, with the instrument showing strong internal consistency and reliability (Cronbach's alpha > 0.8). The final SITI instrument consists of 32 items across five constructs—ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practices, and STEM Teaching—measured on a 7-point Likert scale. This validated instrument provides a reliable tool for measuring ICT integration in STEM teaching within the TPACK context. The study's findings contribute to expanding STEM pedagogy by highlighting the role of contextual ICT integration. The SITI instrument offers educators and policymakers insights into designing technology interventions tailored to the specific needs of STEM educators.

Keywords: STEM teaching, ICT, TVET, TPACK

Pembangunan Instrumen STEM ICT Teaching Inventory (SITI) untuk Pengukuran Pengintegrasian ICT dalam Pengajaran STEM dalam kalangan Pendidik TVETMARA

ABSTRAK

Pendidikan STEM telah mendapat perhatian yang signifikan di peringkat global disebabkan peranannya yang kritikal dalam menyediakan pelajar untuk pekerjaan masa depan dalam dunia yang semakin berteknologi. Menyedari kepentingan ini, Malaysia telah menjadikan pendidikan STEM sebagai keutamaan negara, dengan memberi tumpuan kepada integrasi Teknologi Maklumat dan Komunikasi (ICT) dalam pengajaran STEM. Kajian ini bertujuan untuk membangunkan dan mengesahkan STEM ICT Teaching Inventory (SITI), iaitu satu instrumen yang direka untuk menilai integrasi ICT dalam pengajaran STEM di kalangan pendidik di TVETMARA, sebuah penyedia Latihan Pendidikan Teknikal dan Vokasional (TVET) swasta di Malaysia. Kajian ini berasaskan kepada kerangka kerja Technological Pedagogical Content Knowledge (TPACK) dan menangani faktor kontekstual yang mempengaruhi integrasi ICT dalam pendidikan STEM. Pembangunan SITI menggunakan pendekatan kaedah campuran eksploratori berurutan (QUAL→quan) yang melibatkan tiga fasa pembangunan instrumen. Fasa pertama melibatkan kajian kualitatif yang meneroka integrasi ICT dalam pengajaran STEM melalui temu bual separa berstruktur dengan 10 pendidik TVETMARA, disertai dengan pemerhatian di dalam kelas dan analisis rancangan pengajaran. Analisis tematik menggunakan perisian Quirkos mengenal pasti lima tema utama: Pemilihan ICT, Sokongan Organisasi, Kerjasama Rakan Sebaya, Amalan Pedagogi, dan Penyediaan Pengajaran. Tema-tema ini membentuk pembangunan instrumen SITI, yang menghasilkan lima konstruk awal dengan 42 item di dalam fasa kedua. Fasa ketiga pembangunan SITI melibatkan kajian kuantitatif untuk mengesahkan kesahan kandungan dan konstruk SITI.

Melalui pengesahan pakar dan analisis deskriptif, lima konstruk dengan 42 item dikekalkan. Untuk pengesahan konstruk, instrumen SITI telah diberikan kepada pendidik TVETMARA dalam dua peringkat: eksploratori (n = 162) dan pengesahan (n = 265). Analisis Faktor Eksploratori (EFA) menggunakan IBM SPSS 22 mengurangkan instrumen kepada 32 item merentasi lima konstruk, walaupun konstruk Penyediaan Pengajaran dikecualikan kerana korelasi antara faktor. Analisis Faktor Pengesahan (CFA) menggunakan IBM SPSS Amos 26 mengesahkan kesahan konvergen dan diskriminan, dengan instrumen menunjukkan konsistensi dalaman dan kebolehpercayaan yang tinggi (alpha Cronbach > 0.8). Instrumen SITI yang akhir terdiri daripada 32 item merentasi lima konstruk—Pemilihan ICT, Sokongan Organisasi, Kerjasama Rakan Sebaya, Amalan Pedagogi, dan Pengajaran STEM—diukur pada skala Likert 7 mata. Instrumen yang disahkan ini menyediakan alat yang boleh dipercayai untuk mengukur integrasi ICT dalam pengajaran STEM dalam konteks TPACK. Penemuan kajian ini menyumbang kepada pengembangan pedagogi STEM dengan menonjolkan peranan integrasi ICT secara kontekstual. Instrumen SITI menawarkan pandangan kepada pendidik dan pembuat dasar untuk merancang intervensi teknologi yang disesuaikan dengan keperluan khusus pendidik STEM.

Kata kunci: *Pengajaran STEM, ICT, TVET, TPACK*

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List of abbreviations

MARA	Majlis Amanah Rakyat
SITI	STEM ICT Teaching Inventory
STEM	Science, Technology, Engineering and Mathematics
TPACK	Technological Pedagogical Content Knowledge
TVET	Technical and Vocational Education and Training
IKM	Institut Kemahiran MARA
KKTM	Kolej Kemahiran Tinggi MARA
MJJI	MARA Japanese Industrial Institute
SPMa	Standard Pendidik MARA

CHAPTER 1

INTRODUCTION

1.1 Research Background

STEM education, an acronym for Science, Technology, Engineering, and Mathematics, is a key educational approach that integrates the four disciplines to prepare students for the demands of the modern workforce. By focusing on innovation, problem-solving, and real-world applications, STEM education equips students with critical and creative thinking skills through a focus on innovation, problem-solving, and real-world applications century (Kennedy & Odell, 2014; McGunagle & Zizka, 2020; Sirajudin et al., 2021). These skills are highly valued in the 21st century. However, there is a notable gap between the skills that STEM graduates possess and the competencies required by industries, highlighting the need for educational institutions to reassess their curriculum and bridge this divide (Akcan et al., 2023; Jang, 2016; Lavi et al., 2021). Integrating STEM into educational programs fosters technical expertise and emphasizes creativity and solution-finding, which are essential for thriving in an ever-evolving technological landscape. In this context, high-quality STEM education that integrates science, technology, engineering, and mathematics is crucial in preparing a skilled workforce capable of addressing complex challenges using current tools and technologies (AlAli, 2024; Drakatos & Stompou, 2023; Kelley & Knowles, 2016; Kennedy & Odell, 2014).

The role of Information and Communication Technology (ICT) in STEM education is increasingly significant as it enhances the teaching and learning processes through innovative digital tools and resources. ICT facilitates interactive learning environments that engage students and help them grasp complex concepts by providing visual and hands-

on experiences (Agyei & Agyei, 2021; Chaudhury et al., 2019; Desai & Kulkarni, 2022). For example, digital simulations, virtual laboratories, and educational software allow students to visualize scientific phenomena and experiment with various scenarios in ways that traditional teaching methods cannot offer (Elías et al., 2022). Moreover, ICT in STEM education supports the development of critical skills such as digital literacy, problem-solving, and collaboration, which are vital in today's technology-driven world(Chan & Fitri Suraya, 2019; Çoban et al., 2022; Lukychova et al., 2022a). The integration of ICT also transforms the traditional classroom into a dynamic learning space where students actively participate in problem-solving and design-based learning, mirroring the collaborative nature of professional STEM fields (Krajcik & Delen, 2017; Yang & Baldwin, 2020). However, challenges such as the need for teacher training and the high cost of advanced technologies like augmented reality (AR) and virtual reality (VR) need to be addressed to maximize the potential of ICT in enhancing STEM education (Birzina & Pigozne, 2020). Despite these challenges, the effective use of ICT in STEM teaching is crucial for preparing students to meet the technological demands of the modern workforce (Bentley et al., 2022; Şenyiğit & Serin, 2022; van Laar et al., 2017; Zafar, 2019).

In Malaysia, the digitalization of education has become a strategic priority, aligning with the nation's broader goals of becoming a knowledge-based economy and advancing its position in the global market. STEM education, as an integral part of this strategy, plays a vital role in preparing a skilled workforce capable of addressing complex challenges using current tools and technologies. The Malaysian government has introduced various initiatives, such as the Malaysia Education Blueprint (MEB) 2013-2025, which emphasizes the integration of ICT and STEM into the national education system to enhance the country's competitiveness. The Digital Education Policy and the MyDigital initiative

further highlight Malaysia's commitment to digital transformation, aiming to increase the digital literacy of students and educators while fostering innovation in teaching and learning practices (Idris & Bacotang, 2023; Jamil et al., 2023; Md. Aris et al., 2024). These policies focus on equipping educational institutions with the necessary digital infrastructure, promoting the use of digital tools in classrooms, and encouraging the development of digital competencies among students. Despite these efforts, challenges such as insufficient digital resources, a lack of qualified ICT teachers, and uneven access to technology remain significant barriers to effective ICT integration in education (Chan & Fitri Suraya, 2019; Khairul Anuar et al., 2022; Md. Aris et al., 2024; Rizal et al., 2019).

STEM education is an integral part of the Technical and Vocational Education and Training (TVET) curriculum, where it plays a vital role in enhancing the employability and skill sets of students (Akgunduz & Mesutoglu, 2021; Asunda, 2014; Chan & Fitri Suraya, 2019; Dixon & Hutton, 2016; Reeve, 2016). TVET institutions, such as TVETMARA, incorporate STEM education to provide students with practical and theoretical knowledge that aligns with industry requirements (Unit Naziran dan Kualiti Pendidikan MARA, 2009). This integration creates a rich learning environment that combines technical skills with problem-solving abilities, preparing students for real-world challenges. By emphasizing project-based learning and hands-on applications, STEM education within TVET fosters innovation, adaptability, and critical thinking, skills that are essential for the 21st-century workforce (Dixon & Hutton, 2016; Reeve, 2016). TVETMARA's curriculum focuses on authentic workplace challenges, encouraging students to apply their knowledge from science, technology, engineering, and mathematics in practical settings. This approach not only prepares students to meet the current demands of industries but also

equips them with the competencies needed to thrive in a rapidly evolving professional landscape.

The effectiveness of delivery in STEM teaching influences by teachers' level of expertise and understanding of STEM Education and its pedagogical implementation (Bell et al., 2017). Several scholarly research (Babb et al., 2018; Bell et al., 2017; Novak & Wisdom, 2018; B. Yildirim & Sidekli, 2017) have underscored the significance of technology in the pedagogical development of STEM educators. Therefore, ICT is essential and relevant in improving teaching and learning (Zubković et al., 2022). Consequently, educators in STEM Education must possess the technical proficiency to effectively instruct their respective subjects (Goy et al., 2017; Türk et al., 2018). However, it has been observed educators have a deficiency in their proficiency in using ICT (Chan & Fitri Suraya, 2019). In addition, it is essential to note that educators have difficulty fully utilizing technology because they lack confidence in selecting the most effective pedagogical methods for integrating technology (Azlida & Abdul Halim, 2017; Singh & Chan, 2014). Thus, educators who implement STEM teaching need the required competencies to conduct STEM teaching proficiently.

1.2 Problem Statement

The integration of Information and Communication Technology (ICT) into STEM education is increasingly recognized as crucial for equipping students with the skills needed in the modern workforce. However, in the context of TVET, several critical issues hinder the effective integration of ICT in STEM teaching. These issues are multifaceted, involving a lack of ICT proficiency among TVET educators, insufficient pedagogical knowledge regarding the use of technology in teaching, the inadequacies of existing assessment instruments, and the absence of consideration for contextual factors specific to

TVETMARA settings. This problem impacts the quality of STEM education and the preparedness of graduates to meet industry demands, thereby necessitating a comprehensive investigation and targeted interventions.

One of the primary issues is the lack of ICT proficiency among TVET educators. TVET educators often lack the necessary ICT skills to effectively incorporate technology into their STEM teaching. Particularly, in TVETMARA one of private TVET providers in Malaysia, despite the increasing emphasis on digitalization and technological integration in education, many TVETMARA educators struggle with the basic competencies required to use digital tools in their teaching practices (Chan & Fitri Suraya, 2019). Studies indicate that educators frequently lack confidence in using ICT, have limited skills in operating technology, and often do not know how to select the most effective tools for enhancing student learning (Chan & Fitri Suraya, 2019; Azlida & Abdul Halim, 2017). This deficiency in ICT skills among educators is a significant barrier to the effective implementation of STEM education, as it limits the ability of teachers to create engaging, technology-enhanced learning environments essential for student success in STEM fields (Şenyiğit & Serin, 2022). Without adequate ICT skills, educators are unable to fully utilize the benefits of technology to improve student outcomes and affects the students' readiness for the digital workforce. Therefore, lack of ICT competency issue highlights the need for clear insights into how TVETMARA educators currently engage with ICT as their instructional practices in STEM teaching.

A significant challenge faced by TVET educators is the lack of pedagogical knowledge related to the integration of technology in teaching. This issue goes beyond mere technical skills; it encompasses a deep understanding of how to effectively use technology to enhance teaching and learning processes. As introduced by Mishra &

Koehler (2006), the Technological Pedagogical Content Knowledge (TPACK) framework underscores the importance of blending content, pedagogy, and technology to integrate technology effectively in teaching (Mishra & Koehler, 2006). However, many TVET educators lack a deep understanding of TPACK, which affects their ability to use technology to support STEM teaching effectively (Jang, 2016; Ifinedo & Kankaanranta, 2021). Educators often fail to employ technology in ways that support active, student-centered learning, leading to missed opportunities for enhancing STEM education. Educators may use technology superficially, such as presenting digital slides, without fully engaging students in interactive and innovative learning experiences that modern STEM teaching requires (Bell et al., 2017). Educators often struggle to integrate technology into their teaching methods due to insufficient training and limited exposure to effective pedagogical approaches that incorporate ICT (Bell et al., 2017). This gap in pedagogical knowledge restricts the potential for innovative teaching practices and limits educators' ability to fully utilize ICT in enhancing STEM education (Zubković et al., 2022). Therefore, it is the aim of the study to develop a STEM ICT Teaching Inventory which measures and improves ICT integration in STEM education in TVET educational settings. This will ensure that TVET students are equipped with the skills and knowledge for the 21st century workforce.

Existing assessment tools used to evaluate STEM teaching often focus on affective domains, such as attitudes and beliefs, and general teaching skills without specifically assessing the integration of technology. Traditional instruments fail to capture how educators incorporate ICT into their teaching practices, leaving a significant gap in understanding the extent and effectiveness of ICT integration in STEM education (Kennedy & Odell, 2014). This lack of comprehensive assessment tools means that there is

insufficient data on educators' proficiency and usage of ICT in the classroom, making it difficult to identify areas needing improvement or to measure the impact of ICT on teaching outcomes. This gap highlights the need for an instrument that specifically measures the integration of ICT in STEM teaching specifically in TVET settings such as TVETMARA. The absence of a comprehensive assessment tool evaluating how TVETMARA educators incorporate technology into their teaching practices limits the ability to identify strengths and areas for improvement in ICT integration. This lack of focus on technology in current assessment models means that educators' proficiency and practices in using ICT are not adequately captured, impeding efforts to enhance STEM teaching through effective technology use (Babb et al., 2018; Novak & Wisdom, 2018).

The scholarly discussion on ICT integration in STEM education often overlooks contextual factors specific to TVET settings, particularly those influencing TVETMARA educators. Contextual elements such as institutional support, availability of resources, teacher motivation, and policy frameworks significantly impact how ICT is adopted and used in STEM teaching. TVETMARA operates under unique conditions where educators are often industry practitioners facing challenges like high workloads, limited access to technology, and unclear expectations from stakeholders (Ismail & Hassan, 2013; K. Ismail et al., 2017). These factors create a complex environment that significantly influences ICT integration but is rarely addressed in existing research. Recognizing these contextual variables is crucial for developing relevant models that explain ICT integration practices specific to TVETMARA educators. Thus, the study attempted to identify suitable models that describe and explain these contextual educators' ICT integration practices.

1.3 Research Purpose

The purpose of this study is to understand the practices of STEM teaching integrating ICT by TVETMARA educators. The goal is achieved by developing the STEM ICT Teaching Inventory (SITI) instrument using three distinct phases in a sequential exploratory mixed-method study:

- Qualitative phase
- Integration phase
- Quantitative phase

In the initial phase, the researcher aims to explore the experience of TVETMARA educators integrating ICT in STEM teaching. Based on the findings, she develops SITI instrument. Finally, in the quantitative phase, the researcher seeks to establish the validity and reliability of SITI instrument.

1.4 Research Objectives

The following are the research objectives:

i. To describe the activities that represent the practices of ICT integration in STEM teaching of TVETMARA educators

ii. To validate STEM ICT Teaching Inventory (SITI) instrument

iii. To identify which model is suitable to describe and explain TVETMARA educators' ICT integration practices in STEM teaching

1.5 Research Questions

The study is guided by three research questions:

1) How do TVETMARA educators integrate ICT in their STEM teaching in the lens of TPACK?

   What are the attributes that describe TVETMARA educators' activities in integrating ICT in STEM teaching?

2) To what extent is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integration practices in STEM teaching?

3) Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?

1.6 Significance of Study

Ling et al. (2019) highlight that the Sustainable Development Goal (SDG) underscores the importance of fostering a sustainable, peaceful, prosperous, and fair society through education (Ling et al., 2019). Consequently, it amplifies the need to strengthen STEM education to support human capital development. In addition, students are expected to use their STEM knowledge and abilities to make significant contributions to society. Therefore, there is an urgent need to examine policies regarding adopting innovative teaching methods and training qualified STEM teachers. The STEM ICT Teaching Inventory (SITI) as a self-assessed instrument seeks to provide curriculum developers with information on whether a new ICT-integrated STEM teaching approach is compatible with the knowledge base of teachers who are the primary curriculum implementers. The purpose of this instrument is to assist education administrators and professional development training departments in identifying deficiencies. It can depict teacher proficiency, which is essential when assessing the efficacy of interventions and training provided to STEM educators in TVET.

According to Omar Khaizer et al. (2018), the teaching profession is central to a nation's effort to cultivate its human capital assets (Khaizer Omar et al., 2018). However, many instructors need help attempting to deliver high-quality instruction. Several studies, including those by Ismail & Hassan (2013), K. Ismail et al. (2017), Malloch & Helmy (2015), and Ramadan & Chen (2018), have revealed that teachers face a variety of challenges, ranging from excessive workloads and disciplinary issues among students to unclear expectations from the key stakeholders within the TVET system (Ismail & Hassan, 2013; K. Ismail et al., 2017; Malloch & Helmy, 2015; Ramadan & Chen, 2018) . Given these obstacles, it is crucial to comprehend the perspectives of these instructors. Identifying the factors motivating teachers to remain dedicated and find fulfilment in their careers is equally essential.

Ensuring that TVET institution graduates remain relevant in the long term necessitates a consistently updated and high-quality curriculum. Replacing TVET instructors is especially difficult because they are industry experts. Therefore, it is essential to provide them with motivational programs, appropriate training, and comprehensive induction processes to improve their teaching methods and creativity.

MARA emphasizes the significance of enhancing its educational quality. *Standard Amalan Pendidik MARA* (SPMa) is the foundation for operational management and educational leadership within MARA institutions. In order to reinforce this framework, the proposed STEM ICT Teaching Inventory (SITI) instrument can supplement the existing SPMa. In particular, it can provide valuable indicators for Standard Practice 1.5, which emphasizes the integration of ICT in teaching and learning. Even though Malaysia has established the necessary interventions, the effectiveness of STEM educators training still needs to be discovered (Chong, 2019). It is essential to identify the perspectives of STEM

educators in TVET that allow them to appreciate their teaching careers. Even though educators in TVET may be industry practitioners, training, support, and motivational programs can enhance their teaching creativity. Thus, the proposed STEM ICT Teaching Inventory (SITI) instrument can provide TVETMARA education administrators from the training department with information regarding the level of STEM instructors' ICT integration knowledge.

1.7 Operational Definition

1.7.1 STEM teaching

STEM teaching is an interdisciplinary approach that combines science, technology and mathematics in the field of technical and engineering to create a holistic learning experience of TVETMARA students. By integrating the content and methods of these fields, STEM teaching aims to achieve TVETMARA program educational objectives that encourage students to apply their knowledge and skills in real workplace situations, promoting critical thinking, problem-solving, and innovation (Standard Pendidik MARA, 2009; Asunda, 2014). According to the MARA Education Standard Instrument (SPMa), specifically element 1.4 on Philosophy and Discipline, TVETMARA educators are required to connect and deliver their instruction across different curricula and disciplines. Within the TVETMARA context, technical and engineering courses are often integrated with science, mathematics, and technology, fostering a comprehensive and practical workplace experience.

1.7.2 SPMa

Standard Amalan Pendidik MARA (SPMa) instrument provides additional insights into STEM teaching as a distinctive pedagogical methodology. The SPMa emphasizes the

importance of adopting a cross-disciplinary perspective, suggesting that knowledge should not be confined to individual subjects' boundaries but rather weave through various disciplines to create a tapestry of interconnected comprehension.

In the context of TVETMARA, STEM teaching is not limited to theory or recalling information. Instead, it emphasizes hands-on learning to ensure students can employ their knowledge in the real world. Innovative pedagogical techniques, such as problem- and project-based learning, are the foundation of this methodology. These strategies encourage students to delve more deeply into real-world challenges, simulating situations they may encounter in the workplace. Through this, students acquire knowledge and refine skills directly applicable in professional environments.

1.7.3 TVETMARA

TVET MARA refers to the technical and vocational education and training programs offered by the Majlis Amanah Rakyat (MARA), a Malaysian government agency focused on developing skilled human capital. There are 10 Kolej Kemahiran Tinggi MARA (KKTM), 1 MARA Japanese Industrial Institute (MJII) and 14 Institut Kemahiran MARA (IKM) are educational institutions in TVETMARA. These programs are designed to provide students with practical and industry-relevant skills across various technical and vocational fields, such as engineering, hospitality, business, and information technology. TVET MARA aims to equip students with the competencies required to meet the current demands of the labor market, enhance employability, and support Malaysia’s industrial growth. The curriculum emphasizes hands-on training, industry partnerships, and certification aligned with national and international standards.

1.7.4 TVETMARA Educators

A TVET MARA educator is a qualified instructor or trainer employed by the Majlis Amanah Rakyat (MARA) to deliver technical and vocational education and training (TVET) programs. These educators are responsible for teaching practical and theoretical skills within their specialized fields, such as engineering, technology, business, hospitality, and other vocational areas. TVET MARA educators are expected to possess industry-relevant qualifications, technical expertise, and pedagogical skills to facilitate effective learning. They play a crucial role in preparing students for the workforce by employing hands-on teaching methods, incorporating industry standards, and continuously updating their knowledge to align with evolving industry trends. Their duties include curriculum development, student assessment, skills certification, and fostering a supportive learning environment to enhance students' employability and professional readiness.

1.7.5 ICT Integration

ICT Integration in TVETMARA setting refers to the incorporation of ICT tools and resources within the teaching and learning in TVETMARA standard practices. This integration aims to enhance TVETMARA program educational outcomes by creating interactive, technology-enhanced learning environments that align with industry needs. ICT integration encompasses the use of digital tools, such as computer aided design tools, simulators, IoT, Microsoft Office 365 Education, virtual labs, online learning platforms, and other technological resources, to support the development of practical skills, critical thinking, and problem-solving abilities in TVETMARA students.

1.7.6 TPACK Definition Component

TPACK, or Technological Pedagogical Content Knowledge, is a framework that specifies the categories of knowledge needed to integrate technology into the classroom (Mishra & Koehler, 2006). The TPACK framework incorporates technology into Shulman's Pedagogical Content Knowledge (PCK) concept.

The TPACK framework includes three fundamental types of knowledge:

1. Content Knowledge (CK): This is the teacher's comprehension of the subject matter, including its structures, theories, concepts, and procedures, includes an understanding of the facts and structures of a content domain (Angeli & Valanides, 2009).

In this study context, Content Knowledge refers to TVETMARA educators' subject matter expertise in the TVETMARA curriculum, including the theory of technical and engineering subjects and industrial knowledge.

2. Pedagogical Knowledge (PK): It refers to the knowledge of different teaching and learning approaches, theories of learning, and assessment methods without references to specific content areas. It requires knowledge of classroom management, how students learn, assessment, lesson planning, and other general educational considerations (Mishra & Koehler, 2006; Valtonen et al., 2015).

In this context of study, Pedagogical Knowledge (PK) refers to knowledge of teaching approaches, class management and assessment methods in theoretical and practical classes of TVETMARA.

3. Technological Knowledge (TK): This refers to the ability to use various technologies, including possessing knowledge of the capabilities and limitations of available technologies and the ability to utilize them. Additionally, technology knowledge refers to an interest in developing new technologies (Mishra & Koehler, 2006; Valtonen et al., 2015).

In this context of study, Technological Knowledge refers to ICT knowledge, which is defined as knowing how to operate ICT devices and how to use a multitude of tools/software as well as troubleshoot in problematic situations within TVETMARA institutions.

Four additional knowledge types result from the interaction between these primary knowledge categories:

4. Pedagogical Content Knowledge (PCK): This refers to understanding the most effective instructional strategies for a particular subject (Mishra & Koehler, 2006).

In this study, Pedagogical Content Knowledge is defined as the use of STEM teaching in TVETMARA, combined with other instructional methods, including problem-based learning, project-based learning, inquiry-based approaches, and hands-on activities.

5. Technological Content Knowledge (TCK): This entails comprehending the relationship between technology and content and how technology can support and enhance the comprehension of particular content (Koehler & Mishra, 2009).

In this study, Technological Content Knowledge (TCK) refers to the knowledge of how specific ICT tools are used to support and assist in compounding theoretical and practical course content in the TVETMARA curriculum.

6. Technological Pedagogical Knowledge (TPK): This is the understanding of how the use of specific technologies affects teaching and learning; the knowledge of the existence of specific ICTs, including the knowledge of how to use particular ICTs to enrich communication, enhance connection and collaboration between people and how teaching may change as a result of using ICT.

In this study, Technological Pedagogical Knowledge (TPK) refers to integrating ICT tools to enhance STEM teaching, including communication, collaboration and enhancing students learning.

7. TPACK (Technological Pedagogical Content Knowledge): This knowledge type is central to the TPACK framework and combines the three fundamental categories. It refers to the comprehension of how content (what is taught), pedagogy (how it is taught), and technology (the instruments used) can be integrated to ensure effective teaching and learning (Mishra & Koehler, 2006).

In this study, TPACK refers to the expertise of TVETMARA educators in integrating ICT with STEM teaching within their subject matter.

TPACK emphasizes the interrelationships among technology, pedagogy, and content knowledge, suggesting that effective technology integration in education requires an understanding of these interrelationships.

1.8 Structure of Thesis

The thesis is structured into six distinct chapters. Chapter One of this thesis presents an overview of the study, outlining its research background and contextual framework. It explains the pertinent topics, aims, and importance of the study while delving into the theoretical foundations supporting the research. The anticipated practical implications of the research are also discussed. Chapter Two of this study focuses on conducting a comprehensive literature review. This chapter explores and analyses the fundamental concepts and theories relevant to STEM teaching and the role of ICT. TPACK and Situated Learning Theory are two theories underpinning the study.

In addition, it aims to identify any existing gaps in the literature, which will contribute to developing the conceptual framework for this study. A literature analysis is undertaken in order to get a comprehensive understanding of the current state of research on STEM teaching, the integration ICT, TVET, and technological pedagogical content knowledge (TPACK). Chapter Two provides a comprehensive assessment of previous research on the aspects of STEM instruments included in this study, with a particular focus on the Technological Pedagogical Content Knowledge (TPACK) framework. Additionally, it emphasizes the contextual variables associated with the fundamental ideas in STEM education. The preceding argument informs the development of the STEM ICT Teaching Inventory. Chapter Three of this study presents the research technique, encompassing the research paradigm, instrument development, data collecting procedures, and data analysis. Chapter Four presents the research findings, which were derived through theme analysis and structural equation modeling (CB-SEM). Chapter Five discusses the findings of the study supported by past studies. In conclusion, Chapter Six explores its implications, acknowledges the limits of the study, and proposes opportunities for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 STEM Education and Its Importance

STEM education, an acronym for Science, Technology, Engineering, and Mathematics, is a unique approach to teaching and learning that integrates these four disciplines. This method breaks down traditional barriers between subjects, allowing for a more cohesive and interdisciplinary learning experience. STEM education emphasizes real-world applications, where students engage in designing solutions to complex problems using current tools and technologies (Avdeenko et al., 2021; Breiner et al., 2012; Kelley & Knowles, 2016; Kennedy & Odell, 2014; Türk et al., 2018).

Key features of STEM education include its focus on innovation, problem-solving, and the applied process of understanding complex systems. It encourages students to think critically and creatively, fostering skills that are essential for addressing real-world challenges. In order to prepare students for the demands of the 21st-century workforce, it is important to have high-quality integrated STEM programs that not only integrate the four STEM disciplines but also prioritize innovation and problem solving (Kennedy & Odell, 2014; McGunagle & Zizka, 2020b; Sari et al., 2020) . However, with the gap between graduate competencies and the practical needs of the STEM industries, McGunagle & Zizka (2020) points out there is a need to re-assess current curriculum and programs and collaborate to narrow the gap. They promote a cross-disciplinary method that not only combines the four STEM fields but also emphasizes creativity and solution-finding. By embracing these strategies, educational institutions can better prepare graduates to thrive in

an ever-evolving technological landscape, ultimately bridging the existing gap and enhancing the overall efficacy of STEM education.

The integration of STEM (Science, Technology, Engineering, and Mathematics) education, as emphasized by Kelley and Knowles (2016), is increasingly recognized as an essential approach for preparing students for both scholarly and professional achievement in the 21st century. By linking STEM disciplines through genuine, real-world scenarios, Kelley and Knowles promote an educational framework that transcends conventional, segmented teaching practices. This model integrates engineering design, scientific exploration, technological competency, and mathematical reasoning into the curriculum, cultivating a well-rounded set of skills and knowledge vital for students' future pursuits. In the context of TVETMARA, STEM education plays a pivotal role in enhancing technical and engineering courses through a cross-disciplinary approach. This integration fosters a cohesive learning environment where students apply knowledge from science, technology, engineering, and mathematics to tackle real-world problems.

TVETMARA emphasizes authentic workplace challenges, encouraging students to develop innovative solutions using current tools and technologies. This approach not only breaks down traditional subject barriers but also cultivates critical and creative thinking skills essential for modern industries. The emphasis on real-world applications aligns with the meta-disciplinary model advocated by Kennedy and Odell (2014), and Kelley and Knowles (2016), ensuring that students are well-prepared for the demands of the contemporary workforce. By incorporating elements such as engineering design, scientific inquiry, technological literacy, and mathematical thinking, TVETMARA's STEM teaching practices equip students with the competencies needed to thrive in a rapidly evolving

professional landscape, thereby contributing to the modernization of Malaysia's educational processes as highlighted by Avdeenko et al. (2021).

The introduction of STEM education in Malaysia is a gradual and strategic process, driven by national policies and educational reforms. The integration of STEM education into the national curriculum has been a strategic initiative aimed at enhancing the country's competitiveness in the global economy. STEM education in Malaysia has its roots in the early 1960s when the country recognized the need for a science-oriented workforce to drive national development. The initial push came with the introduction of core science and technology policies aimed at meeting the demand for science-oriented graduates, which began in 1967. The National Science and Technology Enrolment Policy of 1967 was a foundational step in Malaysia's efforts to build a strong base of science-oriented graduates. It laid the groundwork for future policies and initiatives aimed at strengthening STEM (Science, Technology, Engineering, and Mathematics) education in the country. The policy helped to increase the number of students in science and technology fields by setting a target ratio of 60:40 for science to arts students in upper secondary schools and pre-university levels. It is towards an effort to contribute to Malaysia's industrial growth and its transition towards a knowledge-based economy(Edy Hafizan et al., 2017a; Halim et al., 2018; Idris et al., 2023).

The STEM Education or STEM Approach is central to the Malaysia STEM Education Concept (Edy Hafizan et al., 2017b; Jiun Chong, 2019; Siti Hamizah Aspin et al., 2021). It revolves around a dynamic teaching and learning strategy that interweaves science, technology, engineering, and mathematics. This fusion enacts through the practical application of knowledge, skills, and values to real-world problem-solving

scenarios. Critical and analytical thinking are nurtured by immersing students in this integrative approach, fostering creativity and innovation.

Aligned with the Ministry of Education's (2016) vision, the STEM Education Conceptual Framework aspires to cultivate a STEM literate society equipped with a highly skilled and qualified STEM workforce. The Malaysia STEM Education Concept consists of three indispensable components: STEM Field, STEM Education/STEM Approach, and STEM Stream. The STEM Field encompasses traditional disciplines such as Science, Chemistry, Mathematics, Sustainability Foundation, Technical Communication Graphics, and Computer Science and specialized domains like Mechanical Engineering, Medical, Biochemistry, and Computing and Information Systems. On the other hand, the STEM Stream refers to the array of educational pathways accessible to students during their upper secondary school years, allowing them to concentrate on their preferred areas of interest within the vast STEM domain.

This comprehensive framework commences early in a student's educational journey, igniting their passion for STEM from childhood and continuing throughout primary school. During this phase, students actively investigate and explore fundamental STEM concepts. As they progress to lower secondary levels, the focus shifts towards honing their STEM skills through immersive problem-solving activities. The emphasis intensifies as they advance to upper secondary levels, further enhancing their STEM proficiencies. Ultimately, at the tertiary level, STEM Education prepares students to embrace the challenges of STEM careers across diverse industries and communities. In essence, Malaysia's STEM Education Conceptual Framework aspires to nurture a community adorned with deep-rooted STEM expertise and abilities. This unified initiative seeks to unlock the vast possibilities of STEM education, bolstering economies and

preparing the upcoming workforce to thrive in a culture that values innovation and technological mastery.

Over the years, the Malaysian government has made concerted efforts to enhance STEM education. In 2013, STEM was integrated in Malaysia education system by the launching of the Malaysia Education Blueprint (MEB) 2013-2025. This comprehensive reform plan aims to transform the education system from preschool to higher education, emphasizing the importance of STEM for Malaysia's future economic and social development. This includes more hands-on, inquiry-based learning experiences in sciences and mathematics (Foi & Teah, 2022; Idris & Bacotang, 2023). The MEB outlines various strategies, including improving the quality of STEM teaching, enhancing industry-academia partnerships, increasing funding for STEM programs, and addressing gender biases in STEM education and careers(Idris & Bacotang, 2023). Despite these efforts, the country has faced challenges such as a lack of qualified STEM teachers, limited infrastructure resources, and a declining interest in STEM subjects among students(Mohd. Ramli & Awang, 2020) .

To address these issues, Malaysia has introduced an extensive STEM Education Action Plan (2017-2025) to cater to the growing demand for improved STEM education at all levels of schooling (Md. Aris et al., 2024). The strategy is designed to boost student interest and engagement in STEM subjects, elevate the standard of STEM instruction, and fortify STEM-related facilities and support. Emphasis is placed on nurturing students' critical thinking, problem-solving, and teamwork skills. The authorities have also initiated a range of programs like STEM camps, competitions, and outreach activities to involve students and champion STEM education. These endeavors play a vital role in equipping Malaysia's upcoming workforce to navigate the swiftly changing technological landscape.

In today's workforce, STEM education equips learners with the fundamental abilities required for thriving professions in the modern labor market. This interdisciplinary approach cultivates critical thinking, problem-solving, and collaboration skills, which are highly sought-after in high-demand fields. By integrating science, technology, engineering, and mathematics, STEM education fosters innovative thinking and practical skills through active learning methods, such as problem-based, project-based, and research-based approaches (Birney et al., 2021; Glaze-Crampes, 2020; Kennedy & Odell, 2024). This holistic preparation enables students to apply their knowledge in real-world scenarios, addressing the evolving demands of various industries (Oyebola Olusola Ayeni et al., 2024; Waters & Orange, 2022).

Furthermore, STEM education equips students with technical expertise needed for high-demand roles in workforce by emphasizing contemporary technologies such as educational robotics and Industry 4.0 integration (Jiehan et al., 2022). For instance, the incorporation of remote laboratories and robotic arms allows students to gain practical experience, bridging the gap between theoretical knowledge and real-world applications (Jiehan et al., 2022; Kennedy & Odell, 2024). Moreover, to enhance students' practical and creative competencies in workplace, the integration of project-based learning within STEM education fosters collaboration and innovation (Kennedy & Odell, 2024) .This is supported by AlAli (2024) that explores the effectiveness of Project-Oriented Problem-Based Learning (PoPBL) within the context of STEM education in Saudi Arabia. The study focusses on enhancing 21st-century skills which includes digital age literacy, innovative thinking, effective communication, and high productivity among students. The study found a significant increase in the average scores across dimensions of 21st-century in the posttests after the PoPBL intervention. In other words, the study highlights the importance

of innovative teaching methods such as Problem-Based Learning (PoPBL) in preparing students for the demands of the modern workforce.

STEM education offers a comprehensive approach that combines theoretical knowledge, practical application, and professional development. It provides students with indispensable proficiencies of which are fundamental for excelling in sectors characterized by a high demand for skilled individuals (Widya et al., 2019). Hence, STEM education plays a crucial role in shaping the future workforce, providing students with the critical thinking, creativity, and problem-solving abilities necessary to succeed in various high-demand sectors. Educational institutions such as TVET can prepare students for successful careers and drive economic and technological progress by focusing on practical skills, fostering innovation, and enhancing problem-solving abilities.

2.2 STEM Education in TVET

In the modern workforce, STEM education offers essential skills in problem-solving and is highly valued (Asunda, 2014; Jang, 2016; Muzana et al., 2021; Yusoff et al., 2022). In TVET, the goals of teaching are naturally reflected in STEM teaching. The TVET curriculum inherently requires students to integrate content from multiple subject areas, making Project-based learning an effective way to promote STEM teaching and learning (Dixon & Hutton, 2016; Reeve, 2016). By contextualizing STEM concepts within real-world issues, STEM teaching in TVET becomes relevant and easier to comprehend.

Technical and Vocational Education and Training (TVET) is a pathway in education that focuses on nurturing a proficient workforce essential for different sectors by offering hands-on skills and knowledge through structured and non-structured training methodologies (Hassan et al., 2021). As defined by UNESCO, TVET encompasses a wide array of terms such as apprenticeship training, vocational education, technical education,

and career and technical education, all primarily oriented towards the world of work (Hashim & Hamidon, 2022). The significance of TVET in enhancing economic competitiveness is profound, as it facilitates the production of qualified workers whose skills align with labor market demands, thereby preparing the younger generation for employment and augmenting the skills of older workers (Okolie et al., 2021).

Furthermore, TVET plays a critical role in addressing the technological challenges introduced by the Fourth Industrial Revolution, which necessitates highly skilled workers capable of efficiently operating advanced technologies (Mohd Faiz Mohd Yaakob et al., 2020). Additionally, TVET significantly contributes to human capital development, enhances national productivity, and supports organizational transformations in high-performance industries by fostering essential skills such as teamwork, multi-skilling, and job rotations (Mohd Faiz Mohd Yaakob et al., 2020).

The TVET training cycle comprises various essential elements, such as curriculum development, trainee assessment, career guidance, pedagogy, the teaching/learning environment, teacher training, and monitoring and evaluation. These components have important implications for ensuring that Information and Communication Technology (ICT) and the overall fundamental effectiveness of TVET projects (Hassan et al., 2021) are successfully integrated. Through a focus on these elements, TVET aims to cultivate graduates who are not only innovative and creative but also aligned with industry needs, thus adequately equipped to address the requirements of the contemporary workforce (Hassan et al., 2021; Mohd Faiz Mohd Yaakob et al., 2020).

An exemplary illustration of effective TVET implementation can be witnessed in Malaysia's TVETMARA, which was established under the Majlis Amanah Rakyat (MARA). TVETMARA's primary focus lies in equipping students with a combination of

technical expertise and theoretical understanding to fulfil the requirements of contemporary industries. The curriculum at TVETMARA is meticulously crafted to be industry-specific, aligning closely with the labour market's needs and integrating cutting-edge technologies to ready students for the challenges posed by the Fourth Industrial Revolution.

2.2.1 STEM Teaching in TVET

STEM education plays a crucial role in Technical and Vocational Education and Training (TVET) by enhancing the employability and skill set of graduates, thereby meeting the demands of modern industries and economies. By integrating STEM into TVET, a rich learning environment is created that combines practical skills with theoretical knowledge. This fusion fosters innovation and problem-solving abilities, which are essential for the 21st-century workforce (Akgunduz & Mesutoglu, 2021; Said, 2021. The integration of STEM into Technical and Vocational Education and Training (TVET) not only enhances the educational experience by merging practical skills with theoretical knowledge but also plays a crucial role in addressing the skill gaps identified in the workforce. As highlighted by Akgunduz & Mesutoglu (2021) and Said (2021), this integration is vital for fostering the innovation and problem-solving capabilities that are increasingly demanded in the 21st-century job market. The findings from Said (2021) regarding the discrepancies between the perceptions of TVET leaders and the actual workforce requirements in Qatar further underscore the necessity of incorporating STEM training and Industry 4.0 elements into TVET programs. This strategic enhancement will not only equip learners with relevant skills but also ensure that they are prepared to meet the evolving challenges of the modern economy.

Furthermore, STEM education significantly enhances students' ability to grasp complex scientific and mathematical concepts by integrating Science, Technology, Engineering, and Mathematics into a cohesive learning paradigm. This approach helps students develop a deeper understanding of abstract concepts by relating them to real-world problems, thus making learning more relevant and meaningful (Rohendi et al., 2023; Sirajudin et al., 2021). For example, STEM-based learning encourages students to engage in problem-solving processes that mirror real-world situations, thereby improving their conceptual understanding and retention (Rohendi et al., 2023). Moreover, the integration of STEM promotes higher-order thinking skills, such as critical thinking and creativity, which are crucial for tackling complex problems (Sirajudin et al., 2021; Zulfawati et al., 2022). Research indicates that STEM activities, such as problem-based learning (PBL) and project-based learning (PjBL), are effective in developing students' critical thinking skills by challenging them to design innovative solutions to real-life issues, such as reducing traffic accidents (Zulfawati et al., 2022). Thus, STEM education not only equips students with essential knowledge and skills but also prepares them to become innovative thinkers and problem-solvers capable of addressing the complex challenges of the modern world.

Additionally, STEM education emphasizes the development of 21st-century skills, including communication, teamwork, and computational thinking, which are crucial for solving complex problems and are highly valued in the modern workforce (Dare et al., 2021; Muhammad et al., 2020). For example, Dare et al. (2021) used an exploratory case study design to investigate the conceptions of 19 K-12 science teachers after participating in an integrated STEM-focused professional development program. The findings revealed that all teacher participants viewed STEM education as fostering the development of 21st-century skills through real-world problem-solving. Similarly, Muhammad et al. (2020)

highlighted the importance of integrating these skills into vocational teaching practices, underscoring the role of STEM education in creating a student-centered learning environment where collaboration and problem-solving are key. Their descriptive analysis of 157 respondents emphasized the need for vocational education to adapt to the demands of modern industries, where teamwork and effective communication are crucial. Teachers reported that integrating STEM components, such as the Engineering Design Process (EDP) and Project-Based Learning (PjBL), into their curriculum helped students better understand and retain complex concepts by applying them in practical, real-world contexts.

Moreover, the use of technology in STEM learning, such as simulations and animations, significantly aids in the visualization and understanding of scientific and mathematical concepts, making them more accessible to students (Chekour et al., 2022; Sari et al., 2020). Both studies emphasize the critical role of simulations in helping students visualize and comprehend complex scientific concepts. For instance, Chekour et al. (2022) highlight how the PSPICE simulator aids in teaching electrical concepts, allowing students to engage in virtual experiments that simplify the understanding of abstract theories.

Similarly, Sarı et al. (2020) discuss how simulations in a STEM learning environment enhance students' scientific process skills by providing a hands-on learning approach. Chekour et al. (2022) found that students in the experimental group who used simulations scored higher on practical tests compared to the control group, demonstrating a better grasp of electrical concepts. In contrast, Sarı et al. (2020) observed that students exposed to simulation-based learning showed enhanced understanding and retention of scientific concepts. While Chekour et al. (2022) specifically focused on teaching electrical concepts to high school students within a blended learning framework, emphasizing the flexibility and convenience provided by simulations, Sarı et al. (2020) adopted a broader

perspective on STEM education. They examined the impact of simulation-based inquiry learning across various scientific disciplines, focusing more on the development of scientific process skills and STEM awareness rather than solely on academic performance.

Based on these discussions, the study of TVETMARA represents an educational institution that adopts a comprehensive and integrated approach to STEM education. TVETMARA curriculum prioritizes the practical application of STEM disciplines, fostering innovation, and enhancing problem-solving skills. Additionally, TVETMARA utilizes contemporary tools and technologies to offer students authentic learning experiences. By implementing these strategies, its students will be better prepared for the demands of the 21st-century workforce, equipped with the essential skills and competencies to excel in their professional careers that accomplished through STEM education.

The above discussion highlights the critical role of STEM education in enhancing the learning experience and skill set of students, particularly within Technical and Vocational Education and Training (TVET) settings. This directly relates to the research aim of understanding STEM teaching practices in TVETMARA, as it underscores the importance of integrating technology and interdisciplinary approaches to bridge the gap between theoretical knowledge and practical application. By examining the effectiveness of simulations and other technological tools in making scientific and mathematical concepts more accessible, this research aims to explore how TVETMARA can leverage these strategies to improve student outcomes. The findings will provide valuable insights into how STEM education can be tailored to meet the specific needs of vocational training, thereby equipping students with the 21st-century skills necessary for success in modern industries. Through a detailed analysis of current teaching practices and the incorporation

of innovative STEM methodologies, this study seeks to contribute to the development of a more robust and responsive STEM curriculum within TVETMARA, ultimately preparing students for the challenges and opportunities of a rapidly evolving workforce.

2.2.2 STEM Teaching as Pedagogical Practice in TVET

STEM education within TVET represents a substantial progression in equipping students for future employment, promoting innovation, and meeting the changing demands of the industry. It provides a revolutionary educational approach that improves both theoretical understanding and practical learning experiences. Due to its emphasis on hands-on skills and real-world applications, TVET serves as an excellent foundation for the integration of STEM. Incorporating STEM components into TVET does not change the fundamental approach of TVET; instead, it enhances it by incorporating STEM competencies into practical modules and improving analytical skills within theoretical lessons (Yusoff et al., 2022). This section examines the STEM TVET teaching frameworks proposed by previous studies, highlighting key theoretical foundations, practical implementations, and the challenges associated with these frameworks.

2.2.3 STEM Education Frameworks

STEM education frameworks exhibit numerous similarities and differences, illustrating their varied methods of merging science, technology, engineering, and mathematics. A shared feature is the focus on interdisciplinary learning, where the relationships among STEM subjects are emphasized to create relevant contexts for practical applications (Kelley & Knowles, 2016; Zhong et al., 2022). For example, the conceptual framework introduced by Kelley and Knowles (2016) incorporates situated learning, engineering design, scientific inquiry, technological literacy, and mathematical thinking, highlighting the interrelatedness of these fields (Kelley & Knowles, 2016).

Likewise, the framework developed by Abu Khurma et al. (2023) emphasizes the necessity of integrating STEM fields to tackle real-world challenges and equip students for their future careers (Abu Khurma et al., 2023). Both frameworks promote the use of authentic, open-ended problems to improve learning outcomes, consistent with the principles of problem-centered and inquiry-based learning (Thibaut, Ceuppens, et al., 2018).

Nonetheless, there are significant differences in the particular teaching strategies and objectives among these frameworks. For instance, the NRC framework highlights the unique epistemic distinctions between science and engineering, indicating that while science seeks to formulate theoretical explanations, engineering is centered on devising optimal human-made solutions (Simarro & Couso, 2021). This differentiation is not as evident in other frameworks, which frequently view STEM practices as parallel and mutually supportive (Kelley & Knowles, 2016; Simarro & Couso, 2021). Additionally, the classification articulated by Zhong et al. (2022) arranges STEM teaching methodologies into product-driven and knowledge-driven tactics, which are further divided into forward and reverse pedagogical models, represented by project-based learning and reverse engineering (Zhong et al., 2022). This classification offers a systematic approach to executing STEM education, emphasizing both the creation of tangible artifacts and the development of knowledge through scientific exploration and problem-solving (Zhong et al., 2022).

In contrast, Thibaut, Ceuppens, et al. (2018) highlights five crucial principles within the STEM framework: combination of STEM content, real-world problem-focused learning, exploration via inquiry, innovation through creative design, and the collaborative spirit of teamwork, all deeply rooted in a social constructivist learning perspective (Thibaut, Ceuppens, et al., 2018). This framework accentuates the vital role of teacher

mentorship and the essence of collaborative learning, both crucial for secondary education students to foster meaningful conceptual transformations (Thibaut, Ceuppens, et al., 2018). Ultimately, while all frameworks strive to elevate STEM education by weaving together various disciplines and nurturing active engagement, they diverge in their unique instructional methodologies, aspirations, and the significance assigned to the individual characteristics of each STEM field.

Various STEM education frameworks reveal a common emphasis on interdisciplinary learning, the integration of STEM content, and the application of real-world contexts. These frameworks aim to provide a comprehensive understanding of how science, technology, engineering, and mathematics interconnect, thereby enhancing critical thinking, problem-solving, and collaboration skills among students. For instance, frameworks like those proposed by Kelley and Knowles (2016), and Roehrig et al.(2021), stress the importance of connecting STEM subjects through relevant contexts and real-life applications, fostering a community of practice among educators. They also highlight the use of authentic, open-ended problems, and hands-on activities to deepen students' understanding of core ideas and engineering practices.

However, contrasts arise in the specific instructional strategies and pedagogical focuses of these frameworks. For instance, the framework by Zhong et al. introduces a taxonomy of teaching models, including project-based learning (PBL), reverse engineering (RE), scientific inquiry (SI), and troubleshooting/debugging (T/D), each with distinct learning outcomes and processes (Zhong et al., 2022). While the framework by Kelley and Knowles is designed for secondary education and emphasizes the interconnectedness of STEM disciplines through a block and tackle metaphor, Zhong et al. categorize teaching models based on product-oriented and knowledge-oriented outcomes, providing a more

segmented approach to STEM education (Kelley & Knowles, 2016; Zhong et al., 2022). Despite these differences, all frameworks aim to enhance STEM education by promoting critical thinking, problem-solving, and collaboration skills, essential for preparing students for future challenges in STEM fields (Kelley & Knowles, 2016; Zhong et al., 2022; Zulfawati et al., 2022).

Another critical component is developing a conceptual framework that guides educators in creating a research agenda and identifying best practices for integrated STEM education. This framework is built around learning theories and pedagogies that lead to key learning outcomes, emphasizing the importance of teachers having sufficient content knowledge and domain-specific pedagogical content knowledge (Kelley & Knowles, 2016). Additionally, the framework addressed the goals and outcomes for both students and teachers, including STEM literacy, 21st-century competencies, STEM workforce readiness, and fostering interest and engagement in STEM subjects (Dixon & Hutton, 2016). The nature and scope of integrated STEM education is also considered, ensuring its applicability across different educational levels and contexts, from primary to tertiary education (Dixon & Hutton, 2016).

Furthermore, the framework incorporates the epistemic nuances of engineering practices, highlighting the differences between scientific and engineering models, the importance of optimization, and the distinct argumentation styles used in both disciplines (Simarro & Couso, 2021). Finally, the framework should be supported by empirical research and systematic reviews to provide an evidence-based foundation for instructional practices, ensuring that the proposed strategies are effective in improving STEM education (Thibaut, Knipprath, et al., 2018). By addressing these components, STEM education

frameworks can provide a comprehensive and cohesive approach to teaching and learning in STEM, preparing students for the challenges of the 21st century and beyond.

However, there are distinct differences in instructional strategies and pedagogical focuses among these frameworks. Some frameworks emphasize the distinct epistemic differences between science and engineering, while others focus on categorizing teaching models based on product-oriented and knowledge-oriented outcomes. These differences reflect the varied approaches to achieving STEM literacy, 21st-century competencies, and preparing students for the STEM workforce.

Integrated STEM in TVET frameworks reviewed underscores the importance of interdisciplinary approaches to STEM education, emphasizing the integration of scientific inquiry, technological literacy, engineering design, and mathematical thinking. Asunda (2014) provides a comprehensive conceptual framework that integrates STEM into Career and Technical Education (CTE) by leveraging constructivism, situated learning, and systems thinking. This framework aims to create a learning environment where students actively engage in problem-solving and critical thinking, essential skills for modern workplaces.

Similarly, Sujarwanto (2021) focuses on the integration of STEM disciplines in the context of the Indonesian curriculum, emphasizing the importance of aligning STEM education with national educational policies and cultural values. This framework advocates for using engineering design as a core element of STEM education, highlighting the importance of community engagement and a supportive learning model. Both frameworks recognize the need for a holistic approach that connects educational content with real-world applications.

The practical application of STEM integration into TVET varies among the frameworks but generally revolves around problem-based and project-based learning models. Asunda (2014) and Dixon and Hutton (2016) advocate for using real-world problems to facilitate learning, allowing students to apply STEM concepts in meaningful ways. This approach not only enhances student engagement but also ensures that learning outcomes are aligned with industry needs. In contrary, Panita (2021) proposes a framework that incorporates collaborative learning and industry partnerships to enhance the relevance and applicability of STEM education. This model is designed to bridge the gap between classroom learning and industry expectations, preparing students for specific career paths. By integrating industry standards and practices into the curriculum, Panita's framework ensures that students acquire skills that are directly transferable to the workplace.

The TVETMARA curriculum's strong focus on an interdisciplinary approach aligns perfectly with the frameworks outlined in the studies by Sujarwanto (2021) and Asunda (2014). This curriculum is to integrate STEM within the framework of real-world workplace challenges, promoting critical thinking, problem-solving, and adaptability in students. By emphasizing practical applications, TVETMARA guarantees that learners not only master theoretical concepts but also possess the ability to apply this knowledge to actual challenges faced in industry environments.

Asunda's (2014) conceptual framework, which blends constructivism and systems thinking, is especially pertinent here, as it fosters learning environments where students engage in genuine tasks that reflect workplace situations. This methodology is further bolstered by Sujarwanto's (2021) focus on contextual learning and the engineering design process, enabling students to address real-life issues systematically, thus improving their preparedness for the workforce. By integrating interdisciplinary STEM education within

practical, industry-focused contexts, the TVETMARA curriculum empowers students with the essential skills and mindset to thrive and succeed in the rapidly evolving technological landscape of contemporary workplaces.

Upon examining the STEM teaching practices in TVETMARA, it is evident that the integration of integrated STEM teaching frameworks can significantly enhance the quality of STEM education within technical and vocational training contexts. TVETMARA, which aims to equip students with practical and theoretical skills relevant to modern industries, can benefit from adopting a comprehensive STEM framework. This framework should emphasize the integration of STEM content and real-world problem-solving to ensure students develop the critical thinking and practical skills needed in today's technological landscape.

Moreover, based on SPMa, TVETMARA incorporates elements from various frameworks, such as problem-centered and inquiry-based learning, to create a dynamic and engaging learning environment. Emphasizing the unique aspects of each STEM discipline, while also fostering an interdisciplinary approach, can help students appreciate the practical applications of their studies in real-world scenarios. Additionally, recognizing the importance of teacher guidance and professional development is crucial for effectively implementing these practices, ensuring that educators are well-equipped with the necessary content knowledge and pedagogical skills.

The diverse STEM teaching frameworks and tailoring them to the specific needs of technical and vocational education, TVETMARA can develop a robust STEM curriculum. This curriculum will not only prepare students for the demands of the 21st-century workforce but also foster a deeper understanding and appreciation of STEM disciplines, ultimately contributing to a more skilled and innovative workforce.

2.3 Role of ICT in STEM Teaching in TVET

The employment of ICT has played a major role in the development of STEM education by providing state-of-the-art resources and techniques that enhance learning. As Kokaj et al. (2023) indicated, through ICT it is possible to quickly absorb information and process data allowing students to make informed decisions very fast. This study suggests that students receiving enough instruction in ICT have better information management skills than those who have not been taught such concepts. Such ability is essential for building critical thinking as well as problem-solving skills which are necessary for success in STEM careers.

According to Şenyiğit & Serin (2022), integrating ICT with STEM teaching facilitates student engagement and understanding. Their findings show that primary school pre-service teachers with higher perceived ICT competencies were more likely to include STEM subjects in their lessons. Consequently, this relationship implies that the use of ICT in teaching these subjects also affects teachers' attitudes and intentions towards achieving educational outcomes successfully.

By giving students the opportunity to engage with real-world problems and develop multidisciplinary solutions, ICT enables them to acquire critical skills that are essential in today's society. Elías et al. (2022) emphasize the critical importance of ICT in STEM education, particularly in promoting active participation in problem solving and mimicking authentic scientific dilemmas The COVID-19 epidemic highlighted the importance of ICT as the transition to virtual teaching demonstrated its ability to provide engaging and immersive learning experiences. ICT tools such as mobile platforms and devices have been instrumental in creating stimulating learning environments, enhancing digital and STEM skills and preparing students to tackle social science topics effectively.

ICT gives students an opportunity to deal with real-life situations and create solutions from different fields which emphasizes the reason why it is necessary for them to have some vital skills. For example, Elías et al. (2022) are of the view that ICT tools play a major role in STEM education as they encourage active involvement in problem solving by simulating realistic scientific problems The COVID-19 pandemic underscores how crucial ICT has been in education, as virtual teaching showed its capacity for making learning more exciting and interesting. Mobile platforms and devices, among other ICT tools, have revolutionized learning environments into interactive spaces that enhance digital literacy and STEM skills while enabling learners to address socio-scientific issues effectively.

Nevertheless, there are also challenges that stand in the way of great promise of STEM education through ICT. Similarly, Çoban et al. (2022) examine how incorporating VR into STEM can prove beneficial for learners. However, although they concede that virtual reality allows access to remote areas, they raise concerns about high costs associated with this technology plus potential drawbacks. In addition, teachers in training may have a limited understanding of virtual reality technology due to their limited experience and training, which limits their use of these technologies in the classroom.

The use of certain STEM technologies, such as sensor-data systems and computer simulations, is challenging (Birzina & Pigozne, 2020). The research suggests that successful integration of ICT in STEM education depends on teachers' knowledge, experience as well as motivational factors. It therefore calls for a comprehensive training program that enable teachers to effectively utilize ICT tools. This study supported by Lukychova et al. (2022), systematic introduction of ICT into secondary education has brought about positive impacts such as improved efficiency in teaching, higher motivation among students and better-quality knowledge in science.

As Bautista (2022) observed, the application of augmented reality (AR) and mobile-based learning tools under Education 4.0 improves student's learning outcomes. These new technologies do not only enhance the educational process but also require teacher capability training so that their usage can be effective enough. As highlighted by Muzana et al., elearning stem project based learning models have been shown to significantly improve student's ICT literacy skills and problem solving skills thus underscoring the importance of developing critical competencies using ICT for the future needs.

ICT has a wide-ranging and progressive role in STEM education that brings about consequential gains in educational outcomes, skill development and preparedness to face the future. Nonetheless, there are challenges encountered in the provision of ICT such as teacher training, availability of resources and advanced technology adoption. It is critical for educators to have enough knowledge on how to use ICT properly so as to positively impact STEM education and ensure students are well equipped with technological skills required by the ever-changing world.

2.3.1 Enhancing Student Engagement

The integration of Information and Communication Technology (ICT) in STEM education reveals significant impacts on student engagement for various aspects such as interactive learning environments, enhanced engagement and motivation, practical and hands-on learning and inclusive and diverse engagement. This section examines the various ICT tools and approaches used to enhance engagement, comparing similarities and contrasts across different educational contexts and pedagogical methods.

Multiple studies underscore the pivotal role of ICT in creating interactive learning environments that accommodate diverse learning styles. For instance, Chakrabarti and

Fredriksson (2022) highlight the use of specialized educational software, such as Ansys Education Resources, which supports project-based learning and emphasizes societal impact and ethical considerations. This approach not only engages students through visually appealing and interactive content but also aligns with modern pedagogical trends that prioritize real-world applications. Similarly, Prat and Massana (2022) demonstrate the effectiveness of integrating everyday digital tools like calculators, laptops, and tablets in foundational engineering courses. These tools, along with virtual platforms, have led to improved student participation, leveled knowledge, and enhanced academic performance. Both studies highlight the importance of using ICT to make STEM subjects more accessible and engaging.

Furthermore, Krajcik and Delen (2017) and Yang and Baldwin (2020) explore how ICT tools transform STEM classrooms into environments where learners actively construct their knowledge. They argue that incorporating technology facilitates authentic learning contexts, enabling students to access real-world data, collaborate on projects, and engage in design-based learning. This interactive approach not only mirrors professional practices in STEM fields but also prepares students for real-world challenges. These studies collectively highlight the transformative potential of ICT in enhancing the educational experience and preparing students for future careers in STEM.

ICT tools have been shown to significantly boost student engagement and motivation. For example, Deviana (2024) found that using Android media in STEM learning notably increases student interest and improves learning outcomes, as evidenced by higher performance in experimental groups compared to control groups. Similarly, Ilić et al. (2024) highlight the role of digital game-based learning (DGBL) in enhancing motivation, especially when students have prior gaming experience and knowledge of

STEM subjects. These studies suggest that familiar and engaging media can be instrumental in capturing students' interest in STEM.

Additionally, Vasilchenko et al. (2020) examines innovative pedagogical approaches, such as learning-by-making, peer-learning, and flipped classrooms, where students create and reuse instructional video materials. These methods increase motivation and engagement by involving students in the active creation of learning content. This process not only enhances the creators' understanding of the material but also benefits the users of the content. Collectively, these findings indicate that ICT tools and innovative teaching strategies can play a crucial role in fostering student engagement and motivation in STEM education.

Several studies emphasize the crucial role of practical, hands-on learning experiences facilitated by ICT in enhancing student engagement in STEM education. For instance, Sulaeman et al. (2021) highlight the high levels of student engagement achieved through the use of the Engineering Design Process (EDP) in elective science classes. The EDP involves collaborative and design-focused activities, which encourage students to work together to solve complex problems and create innovative solutions. This method not only promotes active participation but also helps students develop a deeper understanding of engineering principles by applying theoretical knowledge in practical, real-world contexts.

Similarly, Tadituri and Naick (2023) discuss the effectiveness of e-learning tools and virtual laboratories (v-Labs) in providing immersive digital environments for STEM education. These technologies enable students to participate in cross-disciplinary learning, allowing them to explore and understand various STEM fields in an integrated manner. Virtual laboratories, in particular, offer a simulated environment where students can

conduct experiments, manipulate variables, and observe outcomes without the constraints of physical lab settings. This flexibility makes STEM subjects more accessible, especially in situations where traditional laboratory resources are limited.

By integrating ICT tools such as EDP, e-learning platforms, and v-Labs, educators can create engaging and interactive learning experiences that cater to diverse student needs. These tools facilitate a deeper understanding of core STEM concepts by allowing students to experiment, explore, and engage with the material in a hands-on manner. As a result, students are more likely to find the subjects enjoyable and relevant, leading to increased motivation and a stronger grasp of the material. Overall, the practical application of ICT in STEM education not only enhances student engagement but also prepares them for future careers by developing critical thinking, problem-solving, and collaborative skills.

The role of ICT in promoting education with equal access to quality learning opportunities is a key focus in several studies, including those by Ezeoguine and Eteng-Uket (2024) and Baharin et al. (2018). Ezeoguine and Eteng-Uket highlight the inclusive potential of artificial intelligence (AI) tools in educational settings. They note that AI can enhance student engagement across diverse demographics by providing personalized learning experiences tailored to individual needs. This adaptability allows AI tools to cater to a wide range of student abilities, learning styles, and backgrounds, making education more accessible and equitable. For example, AI can offer customized feedback, suggest learning pathways based on student performance, and provide support in multiple languages, thus accommodating students from different cultural and linguistic backgrounds. By addressing individual differences, AI tools help ensure that all students have the opportunity to succeed, regardless of their starting point.

Similarly, Baharin et al. (2018) discuss the critical role of ICT in bridging the educational divide between urban and rural areas in Malaysia. They emphasize that ICT has the capacity to democratize access to quality STEM education by providing resources and opportunities that might otherwise be unavailable in underserved regions. For instance, the use of digital learning platforms and online resources can bring high-quality educational content to remote schools, which may lack experienced teachers or adequate facilities. This access can significantly enhance the educational experiences of students in rural areas, leveling the playing field and giving them the same opportunities as their urban counterparts.

Moreover, ICT can facilitate distance learning and virtual classrooms, allowing students from different geographical locations to participate in the same lessons and benefit from the same instructional quality. This capability is particularly important in regions where physical access to educational institutions is limited. By connecting students and teachers through technology, ICT helps overcome geographical barriers and ensures that students receive consistent and comprehensive education.

Both studies underline that ICT, through tools like AI and digital learning platforms, not only enhances engagement and learning outcomes but also plays a pivotal role in creating an inclusive educational environment. By making high-quality education accessible to all, regardless of location or personal circumstances, ICT supports the goal of equitable education. This democratization of learning opportunities helps to reduce disparities in education, contributing to a more inclusive society where every student has the chance to thrive in STEM fields.

While the benefits of integrating ICT in STEM education are well-documented, the specific tools and approaches vary across studies. For instance, Chakrabarti and

Fredriksson (2022) focus on specialized software for engineering education, whereas Deviana (2024) emphasizes the use of Android media. Prat and Massana (2022) highlight common digital tools, while Ilić et al. (2024) explore the impact of gamification. These differences reflect the versatility of ICT in enhancing engagement and suggest that the choice of tools can be tailored to specific educational contexts and objectives.

Moreover, there are variations in the educational contexts examined. While Prat and Massana (2022) focus on university-level foundational engineering courses, Sulaeman et al. (2021) investigate junior high school students' engagement in STEM through the EDP. This diversity underscores the adaptability of ICT tools to different levels of education, from secondary to higher education, each with unique engagement strategies and outcomes.

The integration of ICT in STEM teaching is a powerful strategy for enhancing student engagement. Across various studies, ICT tools have been shown to make learning more interactive, personalized, and practical. These tools support diverse pedagogical approaches, from project-based learning to digital game-based learning, and are effective in fostering critical thinking, creativity, and practical skills. For institutions like TVETMARA, leveraging these insights can lead to more engaging and effective STEM education, better preparing students for the technology-driven global economy. By understanding and implementing the best practices from these studies, TVETMARA can enhance student engagement and ensure that learners are well-equipped for future challenges in STEM fields.

2.3.2 Active Learning

The integration of ICT in STEM education has been extensively studied for its potential to enhance active learning. This section provides analysis of several key studies

exploring the role of ICT tools, including Inquiry-Based Science Education (IBSE), interactive lecture demonstrations (ILDs), virtual laboratories (v-Labs), augmented reality (AR), and interactive videos. By examining these studies, this analysis highlights both the similarities and differences in how these technologies are employed to promote active learning and improve educational outcomes in STEM disciplines.

A common theme across the studies is the emphasis on enhancing student engagement and fostering interactive learning environments through the use of ICT tools. According to Ješková et al. (2022), Inquiry-Based Science Education (IBSE) strategies, when supported by digital technologies, significantly improve students' inquiry skills. In their study, students who participated in IBSE activities demonstrated a marked increase in their ability to formulate questions, design experiments, and analyze data compared to those in traditional learning settings. The study utilized a controlled experimental design, where the experimental group showed a statistically significant improvement in inquiry skills, particularly in determining the accuracy of their scientific investigations, as measured by pre- and post-tests.

This finding aligns with the research by Chaudhury et al. (2019) and Chinge & Hamid (2020), who examined the impact of ICT tools such as simulations and interactive lectures on student engagement and comprehension. These studies utilized mixed methods approaches, combining quantitative assessments of student performance with qualitative feedback. They found that students exposed to simulations and interactive lectures were more likely to participate actively in class discussions and demonstrate a deeper understanding of core STEM concepts. For instance, students engaging with physics simulations reported a better grasp of abstract concepts like electromagnetism and wave-

particle duality, as evidenced by higher scores on concept inventories and more detailed responses in open-ended assessments.

Trúchly et al. (2019) and Bautista (2022) further emphasize the role of virtual laboratories (v-Labs) and augmented reality (AR) in making complex scientific concepts more tangible and accessible. Trúchly et al. (2019) conducted a study involving undergraduate students in a computer networking course, comparing the learning outcomes of those using traditional textbooks and those using v-Labs. The results showed that students using v-Labs scored significantly higher on practical exams and demonstrated greater confidence in performing hands-on tasks related to software-defined networking. The immersive nature of v-Labs, which allowed students to simulate real-world networking environments, was highlighted as a key factor in enhancing their practical skills and understanding.

Similarly, Bautista (2022) explored the effectiveness of AR in teaching cell biology to high school students. The study utilized a quasi-experimental design, where one group used traditional 2D diagrams, and another group used AR tools to visualize cellular processes. The findings indicated that students using AR not only achieved higher test scores but also reported increased motivation and interest in the subject matter. The AR tools enabled students to interact with 3D models of cells and molecular structures, making it easier to comprehend complex biological processes such as mitosis and protein synthesis.

Despite focusing on different aspects of STEM education, all these studies converge on the conclusion that ICT tools play a pivotal role in creating engaging and interactive learning experiences. The empirical findings consistently show that these technologies not only enhance student engagement by making learning more interactive

and visually stimulating but also improve educational outcomes by providing hands-on, practical experiences that deepen understanding and retention of core STEM concepts. This consensus underscores the importance of integrating digital technologies into STEM curricula to foster a more engaging and effective learning environment.

Another shared conclusion is the positive impact of ICT on learning outcomes. For example, the implementation of IBSE has been shown to result in statistically significant improvements in students' accuracy and inquiry skills (Ješková et al., 2022). Likewise, the use of interactive videos, as discussed by Desai & Kulkarni (2022), enhances students' conceptual understanding and academic performance. The consistent finding across these studies is that ICT not only engages students but also leads to better educational outcomes by making learning more effective and efficient.

However, the studies diverge significantly in the types of ICT tools they investigate and their implementation methods. Ješková et al. (2022) focus on IBSE, utilizing digital tools to facilitate inquiry-based learning. This approach is distinct from Chaudhury et al. (2019) and Chinge & Hamid (2020), who examine a broader range of ICT tools, including online learning platforms, hands-on experiments, and blended learning. These studies suggest that while IBSE is centered on developing inquiry skills through structured questioning and exploration, other ICT tools aim to provide a comprehensive learning experience that incorporates multiple teaching modalities.

Another difference lies in the specificity of the educational contexts addressed. Trúchly et al. (2019) specifically explore the use of virtual laboratories in technical subjects like software-defined networking, providing a clear focus on a niche area within STEM education. In contrast, Bautista (2022) and Desai & Kulkarni (2022) address broader applications, such as the use of AR in general scientific education and interactive

videos across various STEM disciplines. This variation in focus illustrates the versatility of ICT tools in catering to different educational needs and settings.

The adoption of emerging technologies like AR and VR is another area where the studies differ. Bautista (2022) highlights the potential of AR to make abstract concepts more concrete, particularly in life sciences. On the other hand, Çoban et al. (2022) discuss the use of VR in providing immersive learning experiences, though they also note challenges such as cost and potential distractions. While both AR and VR offer unique advantages, their implementation and impact vary depending on the subject matter and the available resources.

Despite the benefits, the studies also highlight challenges associated with integrating ICT into STEM education. Issues such as the digital divide, the need for continuous professional development for educators, and the high cost of advanced technologies like AR and VR are common concerns. These challenges underscore the importance of considering the practical aspects of ICT implementation, including ensuring equitable access and providing adequate support for both students and teachers.

The comparative analysis of these studies reveals a shared recognition of the significant role ICT plays in promoting active learning in STEM education. While the specific tools and methodologies vary, the consensus is that ICT enhances engagement, improves learning outcomes, and provides diverse and interactive learning experiences. However, the studies also highlight the challenges and limitations, emphasizing the need for careful planning and support to maximize the benefits of ICT in education. As technology continues to evolve, ongoing research and innovation will be crucial in addressing these challenges and further enhancing the effectiveness of ICT in STEM education.

This evidence is particularly relevant to TVETMARA educators, who often seek to equip students with practical and technical skills necessary for the workforce. The demonstrated benefits of ICT tools, such as improved inquiry skills, deeper understanding of complex concepts, and enhanced practical abilities, provide a strong justification for integrating these technologies into STEM curricula within TVET institutions. Technical and Vocational Education and Training (TVET) focuses on equipping students with hands-on, practical skills that are directly applicable in various industries. The positive outcomes associated with virtual laboratories and augmented reality, which provide immersive and practical learning experiences, align well with the goals of TVET education. These technologies offer students a simulated real-world environment where they can apply theoretical knowledge, thus bridging the gap between theory and practice—a core objective of TVETMARA programs. Understanding how these tools enhance learning can guide TVETMARA educators in selecting and implementing ICT resources that best meet their educational objectives.

The research findings highlight the need for continuous professional development for educators to effectively integrate ICT into their teaching practices. For TVETMARA educators, this means acquiring new skills and knowledge to utilize digital tools and technologies that can enrich STEM education. The studies provide insights into various ICT tools and their pedagogical applications, which can inform the training and support needed for educators. For example, understanding the benefits of augmented reality in visualizing complex biological processes can encourage TVETMARA educators to adopt similar tools in teaching subjects like biotechnology or medical technology. The research also points out potential challenges, such as the digital divide and the high costs associated with advanced technologies like AR and VR. For TVETMARA educators, these

challenges are particularly relevant given the often limited resources in vocational and technical education settings.

The findings can help TVETMARA institutions plan for equitable access to ICT, ensuring all students benefit from these tools regardless of socioeconomic background. Moreover, understanding the potential distractions or technical difficulties associated with ICT use can guide educators in developing strategies to mitigate these issues, ensuring a smooth and effective integration process. The diverse range of ICT tools explored in the studies—ranging from IBSE and simulations to virtual labs and interactive videos—demonstrates the flexibility ICT offers in teaching approaches. This flexibility is crucial for TVETMARA educators who often teach a wide range of technical subjects. By understanding the specific advantages and limitations of each tool, educators can customize their teaching strategies to best suit the content and learning objectives of each course. For instance, using interactive videos to enhance understanding of mechanical processes or employing virtual labs for electronic engineering simulations can be directly informed by the research findings. The integration of ICT in STEM teaching also has significant implications for curriculum development in TVETMARA institutions. The research provides evidence-based insights that can inform the design and implementation of curricula that are more engaging and effective. For example, incorporating ICT-based assessments, like those used in IBSE, can help in accurately measuring students' practical skills and understanding. This ensures that the curriculum not only meets educational standards but also aligns with industry needs, ultimately preparing students for successful careers.

2.4 Theoretical Framework for ICT Integration Practices

Theoretical frameworks that underpin ICT integration practices, focus on how these frameworks guide the understanding and implementation of technologies in education. Two primary theories are highlighted: the Technological Pedagogical Content Knowledge (TPACK) framework and Situated Learning Theory. These theories provide a comprehensive foundation for understanding how ICT integration can enhance teaching and learning, particularly within technical and vocational education settings such as TVETMARA.

The TPACK framework, developed by Mishra and Koehler (2006), extends Shulman's concept of Pedagogical Content Knowledge (PCK) by incorporating technological knowledge. It emphasizes the importance of blending content, pedagogy, and technology to create effective teaching practices. TPACK serves as a critical tool for analyzing how educators integrate technology into their teaching, highlighting the dynamic interplay between these knowledge domains. In 2019, TPACK diagram was upgraded with the inclusion of Contextual Knowledge (XK) that refers to the teacher's knowledge of the environment they work within, including awareness of available technologies, policies, and organizational constraints (Mishra, 2019). This framework is particularly relevant in the TVETMARA context, where integrating digital tools in STEM education is essential to align with industry standards and prepare students for the modern workforce. Hence TVETMARA educators need to be well versed with the scenario and teaching policies that bound their TPACK.

Situated Learning Theory, developed by Lave and Wenger, complements TPACK by emphasizing the role of social and contextual factors in the learning process. This theory posits that learning occurs most effectively within authentic, real-world contexts

and communities of practice. In the TVETMARA setting, situated learning supports the integration of ICT by fostering hands-on, experiential learning that mirrors actual workplace scenarios. It highlights the importance of learning as a social process, deeply embedded within specific environments, and shaped by participation in real-world activities. Together, TPACK and Situated Learning Theory provide a robust framework for understanding and enhancing ICT integration in TVETMARA, supporting the development of teaching practices that are both technologically informed and contextually relevant.

2.4.1 TPACK as Theoretical Framework for ICT Integration Practices

TPACK, which stands for Technological Pedagogical Content Knowledge was first developed by Mishra and Koehler (2006). It is a framework that describes the essential types of knowledge teachers need to effectively integrate technology into their teaching practices. Since teaching is a complex activity that consists of various kinds of knowledge that are fundamental to teaching, TPACK forms the basis of theoretical grounding for developing or understanding the process of technology integration practices in teaching(Celik, 2023; Mishra et al., 2023). They argued that teaching is a complex activity that consists of various kinds of knowledge that are fundamental to teaching. Therefore, researchers need a theoretical framework that guides the analysis by identifying the essential and unimportant elements of teacher knowledge incorporating technology for teaching the subject matter.

Building TPACK based on Shulman's Pedagogical Content Knowledge', Shulman's discussion of teacher knowledge was on the relationship and mutually inclusive domains of content knowledge and pedagogy for developing PCK (Shulman, 1986). In order to get an understanding of how certain elements of a subject are organized, adapted, and presented

for instructional purposes, Pedagogical Content Knowledge (PCK) involves the integration of both content knowledge and pedagogical knowledge. Mishra and Koehler (2006) extended it in the view of teachers integrating technology in the pedagogical aspect. TPACK displays the relationship between technology and teaching that transforms the concept of teaching practices using technology. This framework becomes a cornerstone in educational technology research and teacher education (Mishra, 2019; Phillips, 2016).

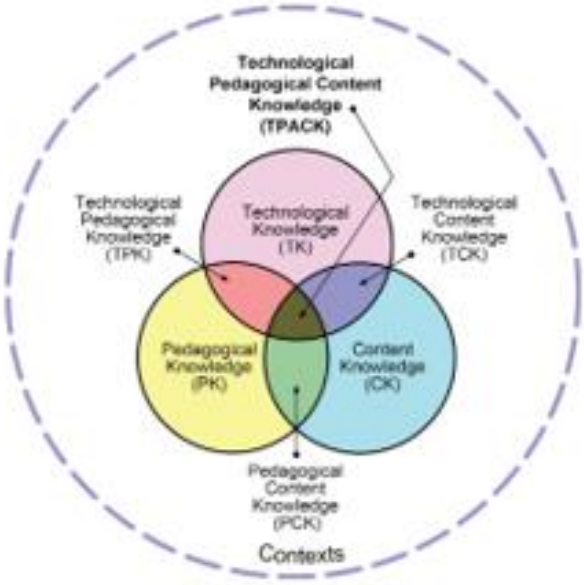


Figure 2.1: TPACK Diagram (Mishra and Koehler, 2006)

The TPACK framework consists of three primary forms of knowledge: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). It emphasizes the intersections between these forms, such as Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Content Knowledge (TCK) (Mishra, 2019).

Content knowledge (CK) in the TPACK framework refers to the understanding of the subject matter that teachers are expected to teach. CK encompasses the facts, concepts, theories, and principles that are specific to a particular discipline, such as mathematics, science, history, or literature. This knowledge is crucial because it forms the foundation upon which teachers build their pedagogical strategies and integrate technology effectively into their teaching practices (Mishra, 2019) . Understanding CK within the TPACK framework is essential for educators to transform their subject matter knowledge into engaging and comprehensible content for their students, leveraging the affordances of digital tools and technologies (J. B. Harris, 2016a) .

Pedagogical knowledge (PK) within the TPACK framework refers to the understanding of teaching methods and processes, including classroom management, lesson planning, and student assessment, which are essential for effective teaching. PK is crucial as it forms the foundation upon which teachers can build their technological pedagogical content knowledge (TPACK), enabling them to effectively integrate technology into their teaching practices(Mishra, 2019). The development of PK within TPACK is often achieved through collaborative instructional design, reflective learning, and problem-based learning, where teachers work together to address specific educational challenges and create effective teaching strategies using technology(J. B. Harris, 2016a). Research has shown that expert teachers distinguish themselves by their richer and more context-sensitive knowledge representations, highlighting the importance of context in the application of PK within TPACK (Brianza et al., 2022) . The highly contextualized nature of teachers' knowledge means that PK must be adaptable to the unique and dynamic environments of different educational settings.

Technological knowledge (TK) in the Technological Pedagogical Content Knowledge (TPACK) framework refers to a teacher's understanding of how to use various technologies effectively in educational settings. This includes not only familiarity with digital tools and resources but also the ability to analyze and apply these technologies to enhance teaching and learning processes. TK involves understanding the affordances and constraints of various technological tools and how they can be used to address specific educational challenges, such as making complex content more accessible and engaging for students (J. B. Harris, 2016a) . This knowledge is crucial for teachers to design and implement instructional strategies that effectively incorporate technology, thereby transforming traditional teaching methods and enhancing student learning experiences (Abdullah & Mahmud, 2024). The development of TK within the TPACK framework often involves collaborative and design-based approaches, where teachers work together to solve practical problems and share expertise in technology, pedagogy, and content(J. B. Harris, 2016a). Moreover, TK is not static; it evolves as new technologies emerge, requiring continuous professional development and adaptation by teachers to stay current and effective in their instructional practices (Abdullah & Mahmud, 2024). The integration of TK with PK and CK forms the basis of TPACK, enabling teachers to create meaningful and technologically enriched learning experiences that are tailored to their students' needs and the specific content being taught (Abdullah & Mahmud, 2024; Brianza et al., 2022).

Pedagogical Content Knowledge (PCK) within the TPACK framework refers to the specialized knowledge that teachers need to effectively teach specific content using appropriate pedagogical strategies. Originating from Shulman's concept of PCK, it emphasizes the intersection of content knowledge (CK) and pedagogical knowledge (PK), focusing on how teachers can make subject matter comprehensible to students through

effective teaching methods (Ifinedo & Kankaanranta, 2021; Rosenberg & Koehler, 2015). PCK involves selecting appropriate teaching methods, planning lessons, and utilizing teaching support facilities to enhance student understanding. TPACK includes PCK as one of its core components, emphasizing the need for teachers to integrate technology into their pedagogical practices to create powerful and understandable representations of content for students (J. B. Harris, 2016a; Rosenberg & Koehler, 2015). This integration is crucial for addressing content-based problems and transforming confusing concepts into clear, teachable moments using digital tools (Abdullah & Mahmud, 2024; J. B. Harris, 2016a).

Technology Pedagogical Knowledge (TPK) within the TPACK framework refers to the understanding of how technology can be integrated into teaching practices to enhance learning outcomes. TPK specifically focuses on the relationship between technology and pedagogy, enabling teachers to understand the advantages and disadvantages of various technological tools in the teaching process (Abdullah & Mahmud, 2024; J. B. Harris, 2016a). This knowledge allows educators to select and utilize digital tools effectively to address specific educational challenges, such as transforming complex content into more comprehensible formats for students. The development of TPK is crucial for teachers to adapt to the evolving educational landscape, which increasingly demands tech-savviness and a deep understanding of the educational potential of digital tools (Brianza et al., 2022). By understanding TPK, teachers can better navigate the complexities of modern educational technologies, ultimately enhancing their ability to deliver content in engaging and effective ways (Abdullah & Mahmud, 2024; Brianza et al., 2022; Mishra, 2019; Phillips et al., 2017).

Technology Content Knowledge (TCK) is a critical component of the Technological Pedagogical Content Knowledge (TPACK) framework, which describes the knowledge required by teachers for effective technology integration in teaching. TCK specifically refers to the understanding of how technology can be used to enhance the teaching and learning of specific content areas. This involves knowing not only the subject matter but also how various technological tools can represent and transform this content to make it more accessible and engaging for students. TCK is essential because it allows teachers to identify content-based problems that students may find difficult and use technological tools to create powerful and understandable representations of this content. This integration is not just about using technology for the sake of it but understanding the affordances and constraints of different digital tools and how they can be best applied within specific disciplinary contexts (J. B. Harris, 2016a). TCK emphasizes the importance of teachers' ability to adapt their content knowledge to leverage technological tools effectively, thereby enhancing student learning outcomes (Abdullah & Mahmud, 2024). This approach requires a deep understanding of both the content being taught and the technological tools available, ensuring that technology is used in a pedagogically sound manner that aligns with educational goals.

2.4.2 TPACK with Context

In 2019, Mishara Koehler upgrades the diagram of TPACK by adding Contextual Knowledge (XK). This is shown in Figure 2.3 . The contextual knowledge of teachers plays a pivotal role in technological integration in educational settings. Teachers' understanding of their specific classroom environments, student needs, and curriculum requirements greatly influences how they implement and adapt technology. This knowledge allows educators to make informed decisions about which tools and methods

will be most effective for their context.(Fleischmann, 2021; Md. Aris et al., 2024) Teachers can employ their contextual experience to adapt the use of technology in order to improve learning results, address particular student difficulties, and match with wider educational objectives (Foulger et al., 2021; Umutlu, 2022). Furthermore, the contextual awareness helps educators navigate potential obstacles and maximize the benefits of technology integration in their unique teaching situations.

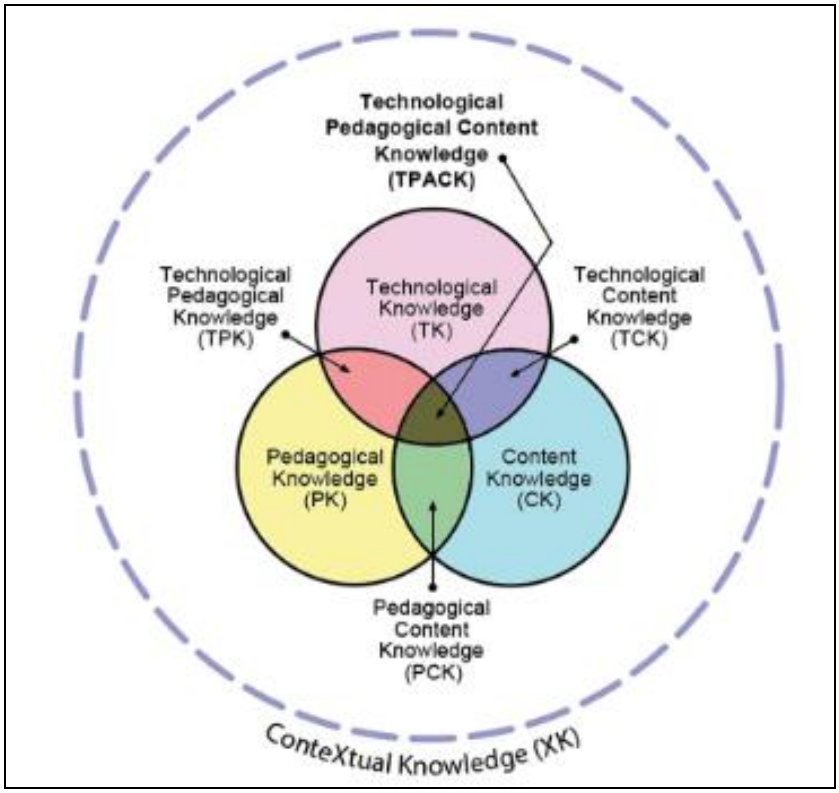


Figure 2.2: Revised Version of TPACK Diagram (Mishra, 2019)

However, the definition of context varies. Context can encompass various elements, including school culture, available resources, student demographics, and community expectations (Mackinnon, 2017; Mishra, 2019; Rosenberg & Koehler, 2015).

Some researchers focus on the physical environment, while others emphasize social and cultural factors. This diversity in defining context highlights the complexity of technology integration in education. Teachers must consider multiple layers of context when making decisions about technology use. Additionally, the dynamic nature of educational settings means that contextual factors are constantly evolving, requiring educators to continually reassess and adapt their approaches to technology integration.

In the TPACK framework, contextual knowledge refers to the teacher's knowledge of the environment they operate within, including awareness of available technologies, policies, and organizational constraints (Mishra, 2019). It emphasizes the importance of considering context as a contributing factor in teaching with technology, highlighting how contextual factors can shape the interactions between pedagogy, content knowledge, and technology (McKinnon, 2017). This contextual understanding enables teachers to make more effective decisions about when and how to integrate technology, ensuring it aligns with their specific teaching goals and student needs. Moreover, contextual knowledge helps educators anticipate potential challenges and adapt their strategies accordingly. For example, a teacher in a rural school with limited internet access might focus on offline digital tools, while an urban educator might leverage online collaborative platforms. By considering these contextual factors, teachers can create more meaningful and impactful technology-enhanced learning experiences that resonate with their unique classroom environments and student populations.

Contextual knowledge of teachers plays a pivotal role in technological integration. The implementation of the Technological Pedagogical Content Knowledge (TPACK) framework, influencing how effectively technology is integrated into teaching

practices. The TPACK framework is inherently "context bound" as it requires adaptation to specific teaching environments, including subject matter, grade level, and student backgrounds. Koehler and Mishra (2009) argues teaching and learning incorporating technology involve a 'dynamic transactional relationship'. Moreover, they emphasized that understanding of complex relationship between content, pedagogy, and technology knowledge helps develop appropriate, context-specific strategies and representations for quality teaching with technology. Hence, TPACK framework places significant emphasis on the contextual factor as a key problem when using technology in educational settings (Rosenberg & Koehler, 2015).

The learning process best occurs when it is part of the learner's context (Lave, 1996). In other words, assigning events about individuals' lives makes the learning perceived as meaningful. Teaching approaches such as authentic context, real-world practice, project-based learning and learning by doing transform learners' roles into active ones. They engage in ill-structured problems that represent the complexity of real-world issues, thus allowing them to control their learning. Learning in context also assists learners to be practitioners through inquiry and collaborative activities.

Numerous studies have explored the role of contextual factors in technology integration, examining the issue from a variety of perspectives. In the domain of teacher education, individual characteristics such as experience, grade level, and subject matter significantly influence technological competence (Carpenter et al., 2020). Carpenter and colleagues (2020) identified that educators with greater experience, whether in K-12 or higher education, generally demonstrate a higher proficiency in utilizing technology. However, context should not be viewed merely as a static backdrop; it is a dynamic and

multifaceted construct that extends beyond physical settings (McDougall & Phillips, 2024). Context encompasses cultural and socially situated processes that create enriched learning environments, essential for the development of Technological Pedagogical Content Knowledge (TPACK). The communal beliefs, traditions, and practices within a learning community play a critical role in shaping how pre-service teachers develop and apply TPACK in authentic educational contexts.

Nonetheless, for in-service teachers, both the educational environment and the individual characteristics of students give impact in shaping effective teaching practices with technology (Brianza et al., 2024). In contrast, study by Lucas et al. (2021) found that among in-service teachers, individual factors such as age, gender, and teaching experience appear to exert a more significant influence on digital competence than school-level contextual factors like classroom equipment, network infrastructure, and school facilities (Lucas et al., 2021). Key predictors of digital competence include the number of tools utilized, perceived ease of use, confidence in technology, and openness to new technological innovations. Nonetheless, the potential barriers presented by both external and internal contextual factors to the development and implementation of technological skills require further investigation. This highlights the need for in-depth understanding of the interplay between personal and contextual factors in the integration of technology within educational settings.

The discussions surrounding the contextual factors from both teachers ‘characteristics and school characteristics are pertinent to the research aim in understanding the practices of STEM teaching within the inclusion of ICT. The dynamic nature of context emphasizes the importance of considering not only the physical and

technological infrastructure of educational settings but also the cultural and social processes that shape ICT integration in STEM teaching. Understanding how communal beliefs, traditions, and practices influence the development and application of TPACK among STEM educators can provide a deeper understanding of the conditions that support or hinder the effective integration of ICT in STEM classrooms in TVETMARA.

According to Lave (1996), the learning content is best supported when it is part of the individual's context. In other words, assigning events about individuals' lives makes the learning perceived as meaningful. Teaching approaches such as authentic context, real-world practice, project-based learning and learning by doing transform learners' roles into active ones. They engage in ill-structured problems that represent the complexity of real-world issues, thus allowing them to control their learning. Learning in context also assists learners to be practitioners through inquiry and collaborative activities.

Prior studies of TPACK that describe context were conducted by various researchers (Angeli & Valanides, 2009; Harris & Hofer, 2017; Mishra & Koehler, 2006; Phillips et al., 2017; Rosenberg & Koehler, 2015).

A holistic discussion of context in TPACK was first addressed by (Porras-Hernández & Salinas-Amescua, 2013). The authors found that the definitions of contexts in the original TPACK model are too limited and general. Moreover, the use of the TPACK model describes teacher training interventions in a pervasive manner. Thus, the context element in TPACK requires further theoretical discussion that includes the introduction of dimensions and placing teachers' variables. Therefore, they proposed a conceptual framework for TPACK research by introducing dimensions, scope and actors in the framework.

According to Porras-Hernández & Salinas-Amescua (2013), contexts include several factors such as students' qualities, classroom and institutional environments for learning, and the teacher's epistemological concepts. The context of students' characteristics has been discussed in Shulman's PCK. The author argued that students' characteristics are an essential condition for the initial conception of teacher knowledge. It is because identifying students' knowledge as a vital element that is necessary for instructional strategies. In Pedagogical Content Knowledge (PCK), he emphasized students' characteristics by including knowledge that understands how specific topics are comprehensible to students through examining conceptions and preconceptions of students from various ages and backgrounds that influence subsequent learning (Shulman, 1986).

Similarly, in the view of TPACK, Mishra and Koehler (2006) describe TPACK as a basis of effective teaching using technology that also requires the understanding of students' prior knowledge to assist teachers in repurposing some available technology tools to meet specific pedagogical goals.

Nonetheless, in a specific TPACK framework for ICT, as illustrated in Figure 1, Angeli & Valanides (2009) highlighted students' components in their ICT-TPCK by adding two elements: knowledge of students and context where learning occurs. In his recent work, Angeli et al. (2016) proposed a computational thinking curriculum framework for designing a curriculum for K-6, which includes internal contexts consisting of students' needs, preferences, misconceptions, learning difficulties, and prior knowledge as sources to understand teachers use of technology. Moreover, cultural, social and economic conditions contribute to students' characteristics (Porras-Hernández & Salinas-Amescua, 2013).

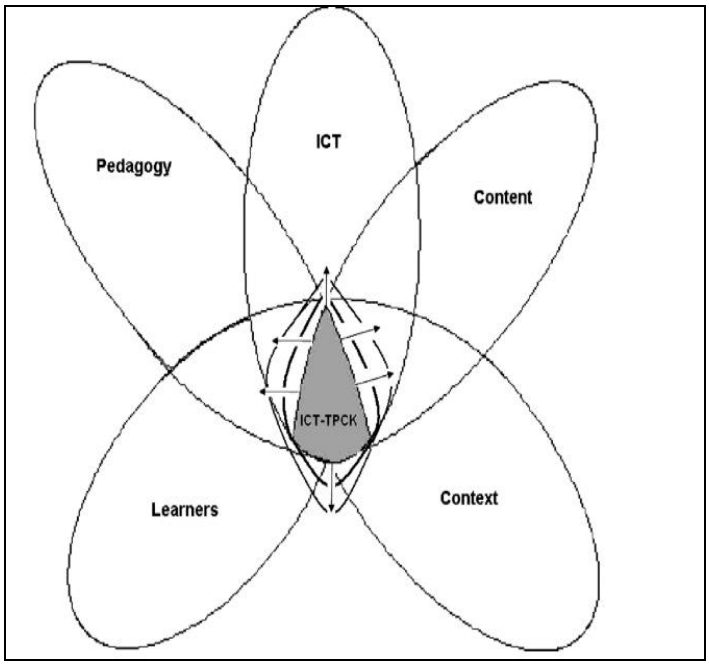


Figure 2.3: ICT-TPCK (Angeli & Valanides, 2009)

On the contrary, the second definition of context, a classroom and institutional conditions, received more attention (Porras-Hernández & Salinas-Amescua, 2013). Similarly, as Buabeng-Andoh (2012) claimed, institutional factors such as support, funding, training and facilities, and system-level factors consisting of curricular and organizational structure also influence teachers' ICT integration practices. Variations of context knowledge and technology knowledge influence teachers' technology integration practices. Shulman addresses it in Those Who Understand: Knowledge Growth in Teaching (1986). Shulman's curricular knowledge demonstrates institutional conditions as a type of knowledge that a teacher should possess. The curricular knowledge consists of information from a program designed to teach particular subjects and topics at any level, and available teaching materials are part of the organizational knowledge in the teacher's mind.

Contextual aspects are recognized as important in the Technological Pedagogical Content Knowledge (TPACK) paradigm (Koh et al., 2014; Mackinnon, 2017; Rosenberg & Koehler, 2015; Swallow & Olofson, 2017).

Previous research has illustrated the impact of contextual factors in both the classroom and school environment as they relate to teachers. However, evidence suggests that TPACK research often needs more clarity in terms of context. According to Rosenberg and Koehler (2015), the context includes various settings where technology-aided teaching occurs, such as different classrooms and school environments. It encompasses factors such as subject matter, grade level, student background, available technologies, and societal influences. A systematic review of TPACK research by the author revealed that context was incorporated in descriptions, explanations, or operationalizations of TPACK in only 36% of the 193 empirical journal articles examined. The author concluded that including context in TPACK research is vital for understanding the complexities of teaching with technology and its effectiveness in various settings. This approach enables researchers to explore the conditions under which TPACK is most effective and supports teachers, parents, administrators, and stakeholders in making changes to educational practices. Analyzing context across diverse settings can also enhance our understanding of TPACK and its development and enactment and strengthen our comprehension of teaching with technology in underrepresented settings, such as high-poverty urban schools.

The inclusion and interpretation of context in TPACK research are highly variable, with different studies examining various contextual factors. Mackinnon (2017) contends that context can significantly influence pedagogy, technology, and content independently. The inclusion of a second language in the curriculum introduces additional complexities to

the classroom environment, including both cultural and linguistic challenges. The authors suggest that the TPACK model has the potential to assist scholars and professionals in examining classroom interventions and constructing technology-use studies that are tailored to specific contextual conditions. This is achieved by considering the breadth and individuals involved in the environment.

Koh et al. (2014) conducted a further inquiry that produced an established framework known as TPACK-in-Action, which illustrates the interplay of TPACK and four contextual factors, namely physical and technological, cultural and institutional, and interpersonal and intrapersonal domains, that significantly influence teachers' ICT lesson design. The study found that when the logistics of lesson implementation dominated group discussions, it curtailed the emergence of TPACK. Conversely, when intrapersonal factors such as beliefs of teaching and students were articulated and their pedagogical implications considered, it facilitated TPACK.

The TPACK framework has undergone modifications and extensions to integrate more contextual factors, such as TVET settings. A recent investigation by Nurzal Effiyana Ghazali and Nor Farahwahidah Abdul Rahman (2023) underscores the importance of engineering educators possessing the necessary prerequisite knowledge to integrate artificial intelligence (AI) into their classrooms. In the context of the Technological, Pedagogical, and Content Knowledge (TPACK) framework, it is of utmost importance to comprehend its significance as a fundamental model for the professional knowledge of engineering educators, particularly when integrating artificial intelligence into pedagogical methodologies. The present investigation delves into the essential knowledge that engineering instructors must attain, as guided by the TPACK framework, before delivering

instruction that utilizes artificial intelligence. Thus, future research should examine how engineering educators can cultivate fluency, cognitive flexibility, and a nuanced awareness of the relationships between content, pedagogy, and technology in diverse contextual settings.

Past studies have conducted research on TPACK with the influence of contextual factors. In a quantitative study, Andyani et al. (2020) analyze how teachers' Technological Pedagogical Content Knowledge influences their usage of ICT in the classroom. The study found that Technological Pedagogical Content Knowledge influences the use of ICT in pedagogy, and organizational innovative climate affects teachers' self-efficacy and the use of ICT in pedagogy. It sheds light on the elements that shape the implementation of ICT in education.

The findings suggest that improving teachers' Technological Pedagogical Content Knowledge and creating an innovative organizational climate can lead to increased use of ICT in pedagogy. This can have practical implications for educational institutions and policymakers who are interested in promoting the use of ICT in education. By investing in training programs that improve teachers' Technological Pedagogical Content Knowledge and creating an innovative organizational climate, educational institutions can create an environment that encourages the use of ICT in pedagogy. This has the potential to improve the quality of education provided to students.

Teachers should identify the kinds of knowledge that require such an outcome(Koehler et al., 2014). Angeli and Valanides (2009) suggested context as a range of classroom conditions and institutions that include teachers' beliefs and philosophical

views when integrating ICT. Hence, it is crucial to address classroom and institutions' reference as context since different educational settings differ in practices.

One of the forms of teacher knowledge that Shulman described was propositional knowledge – Maxims. Maxims are teachers' practical experience and wisdom of practice that can be a great source of guidance other than theory and empirical principles (Shulman, 1986). It is referred to as the third reference of context-situated teaching activities. Teachers learning for teaching and incorporating strategies can be promoted through their practical experiences. It is also can be done learning by design (Koehler & Mishra, 2005).

In the context of TVETMARA, TPACK is a valuable tool for studying STEM teaching from a different perspective on promoting and developing STEM teachers' practices with elements highlighted in TVET. STEM education places a strong emphasis on problem-solving, critical thinking, and the application of knowledge to real-world scenarios. In integrating ICT in STEM teaching, TPACK offers a structured teacher knowledge framework that ensures that technology is not only an add-on but is strategically integrated into pedagogy and content. By utilizing TPACK, educators can better align their teaching practices with the evolving needs of STEM disciplines, facilitating the development of 21st-century skills among students. Furthermore. TVETMARA is a significant platform for developing technical skills and knowledge, aligning with the country's industrial and economic needs. Integrating ICT into TVETMARA's STEM education requires a framework that supports effective teaching strategies and meaningful technology use. The TPACK framework provides TVETMARA educators with the necessary guidance to effectively incorporate technology into their STEM curriculum, enhancing both teaching and learning outcomes.

With TPACK, TVETMARA educators can use ICT tools to present STEM content more interactively and engagingly. For instance, multimedia presentations, simulations, and virtual labs can be used to explain complex scientific and engineering concepts, making them more accessible to students. This approach aligns with Technological Content Knowledge (TCK), which emphasizes the integration of technology to enhance understanding of subject-specific content.

2.4.3 Situated Learning Theory

In Situated Learning Theory, learning is a social phenomenon that occurs through experiences gained in a community of practice (Lave, 1996). Learning becomes integral to general social practice, such as in schools and workplaces, in the context of situated activities. The community of practice determines the knowledge and skills its members must acquire to obtain community membership. From a Situated Learning Theory perspective, learning is an individual process of understanding how to participate in a community of practice and its practices. Teachers have enhanced professional knowledge and practice advantages when they are part of educational institutions with well-established professional learning communities (Pitsoe & Maila, 2013).

Since classrooms provide potent contexts for learning in a school community of practice, teachers become instructional designers of their learning environments where situated activities are pertinent for their learning. In light of ICT integration practices, teachers need training in personalized, sustained, and situated technologies based on their schools' technology resources (Liao et al., 2017). Teachers will learn about the use of technology tools useful for their teaching and learning purposes that suit their curriculum. Hence, technology integration needs to be authentic and effective (Kopcha, 2012). In their

educational contexts, teachers can better visualize technology's integration based on the accessibility of the school resources.

During the early 1990s, Jean Lave and Etienne Wenger developed a theoretical framework known as situated learning, which emphasizes the significance of environmental context and social interactions in the process of education and personal growth. Given the assumption that learning is deeply embedded into the social and cultural context in which it occurs, this theory challenges the traditional notion of learning as a mostly internal cognitive activity.

At the heart of localized learning theory is the idea that learning is best understood when it is set in authentic, real-world contexts. Learners are valued more for their contributions to a community of practice than for what they learn in a classroom. A "community of practice" is a network of professionals who have collaborated to create shared practices and standards.

According to Cobb and Bowers (1999), fundamental principles of the Situated Learning Theory include:

1. Learning in Context

   Learning optimization occurs when it is situated inside authentic contexts that closely resemble its intended applications. Several factors influence education, including the environment, activities, and relationships.

2. Social Participation

   Learning is a social process. Individuals learn by engaging in social interactions, collaborating, and participating in shared activities.

3. Legitimate Peripheral Participation

Beginners start by observing and participating in less central or complex activities within a community of practice. As they gain experience and expertise, they gradually move toward more central and advanced roles.

4. Meaning and Identity

Learning is about acquiring information and developing a sense of identity within a particular community of practice. Individuals adopt the ways of thinking, behaving, and communicating characteristics of that community.

5. Learning as Doing

Learning is not separated from doing; it is an integral part of engaging in meaningful activities. Knowledge is acquired through hands-on experience and problem-solving.

The Situated Learning Theory has been applied to various educational settings and practices, highlighting the importance of creating authentic learning environments, fostering collaboration among learners, and connecting learning to real-world applications. It emphasizes that learning is not isolated from the world around us but is intrinsically connected to our interactions, experiences, and participation in communities of practice.

The present study adopted a contextual learning strategy within the TVETMARA community of practice in order to examine the potential use of information and communication technology (ICT) for enhancing STEM instruction. TVETMARA is renowned for its pedagogical approach that prioritizes experiential learning and the application of knowledge to address real challenges. This initiative is based on the

experience and competence of educators in the field of TVETMARA, who demonstrate authentic and efficient use of information and communication technology (ICT) resources. Moreover, the educators of TVETMARA possess extensive knowledge and expertise in STEM teaching and a thorough understanding of the prevailing information and communication technology (ICT) resources inside the TVETMARA framework. The strategies used for learning inside the workplace have undergone development similar to those seen in the TPACK study (J. B. Harris, 2016b). In other words, instructors' daily activity within communities promotes workplace learning development in the context of Technological Pedagogical Content Knowledge (TPACK).

2.5 Past Instruments Used in STEM Education Research

STEM education becomes the platform for preparing students as the future workforce in 21st Century. It emphasizes the interdisciplinary of science, technology, engineering and mathematics. As the significance of STEM Education grows, there is a need for robust and reliable instruments to assess and enhance its implementation. Several studies on developing instruments in STEM education research focus on teachers' professional development, student engagement and effectiveness of teaching methods. This section analyses the current state of instrument development in STEM education research, identifies existing gaps and relates the findings to the aim of study to develop a STEM ICT Teaching Inventory (SITI) in TVET.

Table 2.1 shows the list of instruments used in STEM Education research. The table outlines the key characteristics and limitations of six instruments used in STEM education research from Malaysia, Indonesia and Turkey. While these instruments provide valuable insights into STEM teaching practices, instructional preparedness, attitudes, knowledge, and application, they face challenges related to generalizability, depth of data,

contextual relevance, and the ability to establish causal relationships. Addressing these limitations enhance the effectiveness and applicability of these instruments across different educational and cultural settings.

Instruments used in STEM education research vary widely, ranging from surveys to performance-based assessments, each to measure specific variables within diverse educational settings. Some instruments focus on teacher preparedness and self-efficacy, while others measure teachers' attitudes, knowledge, and application skills in STEM subjects. This variety reflects the multifaceted nature of STEM education, which requires both educators and learners to engage with interdisciplinary and integrative teaching approaches.

From the teacher knowledge perspective, interdisciplinary knowledge is a crucial variable required to implement STEM teaching effectively (Karpudewan et al., 2020 ; Yildirim & Sahin Topalcengiz, 2019; Ananthan et al., 2022). Interdisciplinary knowledge facilitates the integration of diverse disciplines, enhancing the learning experience to be relevant and more meaningful. The qualitative findings in the study of Karpudewan (2020), interdisciplinary knowledge and related pedagogical strategies emerged as one of the themes for STEM teaching practices. Further in exploratory factory analysis, the item of interdisciplinary knowledge and related pedagogical strategies explained 12.4% from total variance which highlights the significance of the item in STEM teaching instrument. The importance of interdisciplinary knowledge is also highlighted in STEMPCK instrument by the positive correlations between different knowledge dimensions, such as pedagogical, mathematical, and science knowledge, which are essential for a holistic STEM education approach (Yildirim & Topalcengiz, 2019). Hence, through the interdisciplinary approach,

teachers are knowledgeable in each discipline and understand their interconnectedness, which is vital for applying STEM concepts effectively.

Focus on teachers' professional development, the effectiveness of professional development programs and participants' TPACK, evaluate in the interdisciplinary knowledge. The DECODE model, developed by Wahono et al. (2022), provides a structured approach to online STEM professional development, focusing on the integration of technology and pedagogy. This model emphasizes demonstrations, collaborative training, and reflective debriefing, which help teachers enhance their Technological Pedagogical Content Knowledge (TPACK) . The model has been validated for its effectiveness in improving teachers' capabilities in STEM teaching and offers a framework for designing professional development programs (Wahono et al., 2022). In other words, interdisciplinary knowledge not only reinforces learning across all STEM fields but also encourages collaboration and communication among teachers.

STEM education research takes place not only within formal educational settings, such as schools and universities but also informal and non-traditional settings. In formal educational settings, these environments provide structured curricula and established educational standards, offering a controlled setting for implementing and assessing STEM initiatives. Instruments like the STEMTIP and STEMPCK are particularly designed for such settings, evaluating the preparedness of teachers and preservice teachers to deliver STEM content effectively. STEM education research also extends to informal settings that offer opportunities for experiential learning and the application of STEM knowledge in real-world contexts. For instance, instrument AKA that measures attitude, knowledge and application of STEM among Indonesian secondary science school teachers allow for innovative teaching methods that are not feasible in formal classrooms (Wahono & Chang,

2019). Moreover, instruments that focus on performance based assessments capture knowledge application of hands-on activities and real-world problem-solving (Wahono et al, 2022).

Teachers play a critical role in shaping STEM learning experiences and outcomes. Assessing from teacher-related variables, STEM education research emphasizes on teacher preparedness and self-efficacy. Instruments such as STEMTIP (Ramli et al., 2020) and used by Karpudewan et al. (2020) highlight the importance of equipping teachers with necessary knowledge, skills and confidence to implement STEM teaching effectively. Therefore, for teachers to remain relevant and connected with STEM teaching strategies, isntruments to evaluate effectiveness continuous professional development is essential for maintaining high standards of preparedness and self-efficacy (Wahono et al., 2022; Ramli et al., 2020).

However, limitation in generalizability and contextual applications is challenging in STEM instruments. These instruments are developed to specific educational setting, cultural contexts and population groups. For instance, instrument developed by Wahono et al. (2022) to evaluate the effectiveness of professional development program only applicable to Indonesian context. Moreover, instruments that are used in STEM education research need to consider cultural differences and socio-economic factors that influence teaching and learning outcomes. Instruments that lack cultural sensitivity are not accurately capture the diverse experiences of teachers. Thus, instruments can not be applied across different educational contexts.

The advancement of technology and its integration in educational practices create a need for specialized tools to guide STEM teaching framework. While existing instruments in STEM education research offer valuable insights into various aspects of teaching and

learning, they are lack off comprehensive technological integration specifically for TVET settings. With the development of STEM ICT teaching inventory (SITI) , it aims to provide a more holistic and practical tool to address the unique needs of STEM education within TVET environments, where the alignment between industry and education is crucial.

Based on list on instruments in Table 2.1, they primarily focus on assessing teacher preparedness, attitudes, and STEM knowledge application. While these instruments provide valuable data on pedagogical content knowledge (as seen in instruments like STEMTIP and STEMPCK), they often lack a robust framework for integrating specific ICT tools into STEM teaching. The limited incorporation of ICT components means that these instruments do not fully address the technological aspects essential for modern STEM education, especially in vocational training where hands-on experience with technology is crucial.

The STEM ICT teaching inventory explicitly incorporates ICT digital technologies into the assessment of STEM teaching practices. By focusing on the ICT integration into STEM teaching, this inventory can better prepare TVETMARA educators to use ICT tools effectively. It supports educators in selecting, implementing, and evaluating ICT resources that align with industry standards, thus enhancing the relevance and applicability of STEM education in real-world contexts.

Many current instruments measure interdisciplinary knowledge and pedagogical strategies (e.g., the studies by Karpudewan et al. and Yildirim & Sahin Topalcengiz). However, these instruments often do not extend beyond theoretical knowledge integration to practical applications of STEM concepts using ICT tools. The focus tends to remain on traditional teaching methods without sufficiently incorporating the technological tools that facilitate interdisciplinary STEM education.

Table 2.1: Current Instruments in STEM Education Research

Literature Sources	Function of Instrument	Variables	Limitation
Karpudewan et al. (2020)	Measurement of STEM Teaching Practices: to measure the factors that explain STEM teaching practices among Malaysian science and mathematics teachers	Knowledge of Interdisciplinary and Related Pedagogical Strategies; Perceived Difficulties in STEM Teaching Practices; Teachers' Self-Efficacy Beliefs: STEM Teaching Practices:	A limitation in the depth of data collected regarding institutional support; a limitation in the depth of qualitative data collected; a limitation in establishing causal relationships between these factors and teaching practices; the study may not have comprehensively explored all external factors affecting STEM teaching
Ramli et al., (2020)	STEMTIP is designed to measure the instructional preparedness of teachers in the context of STEM education. This involves assessing how well teachers are prepared to implement STEM curricula and teaching methods	Instructional preparedness and Self efficacy	limit the generalizability of the findings to a broader; emphasizes the unidimensionality of the instrument, but there was a signal of a second dimension population of STEM teachers in Malaysia

Table 2.1 Continued

Wahono & Chang (2019)	The AKA instrument is designed to measure three main domains related to STEM education: attitude, knowledge, and application. These domains are specifically assessed among science teachers	STEM Attitude ; STEM Knowledge; STEM Application	designed to measure the general quantitative level of STEM education, making it unsuitable for specific activities like pre-test and post-test evaluations in STEM workshops; limits its applicability and generalizability to other countries and cultural contexts; not fully address all aspects of STEM education measurement as it stands; limit its effectiveness in different educational environments
Wahono et al. (2022)	to evaluate the effectiveness of the professional development program and the participants' progress; categorized into self-assessment surveys (6 TPACK areas) and performance-based assessments;	Teacher's critical abilities, technological and pedagogical competencies, familiarity with technology, assessment and instructional design skills, reflection and adaptability	findings may not yet be fully generalizable or tested in diverse real-world settings; the current study's findings are primarily applicable to the Indonesian context; involved only three experts, which might limit the breadth of perspectives and feedback on the package's effectiveness and applicability; limited access to technological resources or infrastructure;

Table 2.1 Continued

Yildirim & Sahin Topalcengiz, (2019)	STEMPCK to measure the STEM Pedagogical Content Knowledge of preservice teachers. It evaluates their understanding and knowledge in teaching STEM subjects effectively	STEM PCK 6 factors – 21st century skills, Pedagogical Knowledge, Mathematics, Science , Engineering, Technology	limits the generalizability of the findings to other departments or educational contexts; may not fully represent the diversity of STEM disciplines; may not cover all possible areas of pedagogical content knowledge needed for effective STEM teaching;
Ananthan et al., (2022); Karpudewan et al. (2022)	Measure STEM teaching practices	STEM teaching practices, Interdisciplinary education, teacher competency, 21st century skills)	limits the generalizability of the findings to a broader population does not allow for the examination of changes over time or the establishment of causal relationships - may not address other important educational factors such as socio-economic influences or cultural differences that could impact the effectiveness of STEM education

In contrary, SITI emphasizes the practical application of interdisciplinary knowledge through the use of ICT. It provides guidelines for integrating tools such as simulation software, coding platforms, and online collaborative tools, which facilitate a hands-on, project-based approach to STEM education. This inventory supports the development of critical thinking, problem-solving skills, and creativity, which are essential for interdisciplinary learning and are highly valued in the job market.

While contemporary models such as the DECODE framework (Wahono et al., 2022) concentrate on fostering professional advancement in technological and educational methodologies, they often exhibit limitations in comprehensiveness and adaptability, particularly when addressing the dynamic nature of ICT within STEM education. These frameworks lack the provision of continuous support or adaptability to varied educational environments and resource availabilities, thus curtailing their effectiveness across diverse TVET settings. Conversely, SITI is crafted as an ever-evolving instrument that keeps pace with technological breakthroughs. It presents a well-structured assessment mechanism for ongoing teacher professional enhancement, guaranteeing that educators remain informed about the newest ICT innovations and instructional methodologies. This inventory also adapts seamlessly to different levels of technological access, rendering it appropriate for a wide array of TVET environments. By fostering perpetual learning, this inventory empowers TVETMARA educators to uphold exceptional standards of technological proficiency and pedagogical strategies.

One of the major constraints facing contemporary STEM educational tools is their deficiency in broad applicability and situational significance. Numerous resources are crafted for particular cultural or educational landscapes, like the Indonesian framework underscored in Wahono et al.'s research. These tools might fail to genuinely capture the

requirements of diverse areas, socio-economic strata, or educational frameworks, diminishing their usefulness and impact. Thus, SITI is crafted with the essence of versatility and responsiveness. It can be customized for various cultural and educational landscapes, enhancing its significance in a multitude of TVET settings.

2.6 Past Studies on STEM Teaching with ICT

The incorporation of ICT into STEM education is significantly reshaping the educational environment. As key players in this transition, educators have the opportunity to utilize ICT tools to improve learning outcomes and encourage increased student engagement. This section explores educators' perspectives on the incorporation of ICT in STEM education, referencing empirical data from past studies. By investigating the advantages, obstacles, and essential support structures for successful ICT integration, this analysis aligns with the goals of the study which is to look into the contextual factors of TVETMARA educators in integrating ICT in STEM teaching.

Educators across the board recognize the critical role of ICT in advancing STEM education. For those in higher education, ICT is essential for delivering high-quality, effective teaching (Manzano, 2023). Tools such as PowerPoint presentations, word processing applications, and other digital resources are crucial in making complex scientific concepts more understandable and engaging. This view is further supported by (Şenyiğit & Serin, 2022), who highlights that ICT facilitates interactive and student-centered learning environments, which are vital for STEM education. Moreover, the research reveals that teachers' confidence in their ICT skills significantly influences teachers’ willingness to integrate ICT technologies into STEM teaching practices. However, the integration of ICT in STEM education extends beyond mere tool usage. It fosters a dynamic learning environment where students can actively engage with complex

concepts through simulations, virtual experiments, and data analysis software(Monther Al Damen, 2021; Yang & Baldwin, 2020c). The hands-on approach enhances critical thinking and problem-solving skills, preparing students for the technological demands of the modern workforce. Additionally, ICT enables collaborative learning experiences, allowing students to work on projects remotely and share ideas across geographical boundaries. As technology continues to evolve, educators adapt their teaching methods to fully harness the potential of ICT in STEM education.

The effective integration of ICT in educational settings has the potential to enhance students' engagement and interest in STEM subjects, as evidenced by the findings of Brizana and Pigozne (2020). However, the predominant reliance on technology for mere information retrieval indicates a significant gap in its application for fostering creativity and innovation among learners. This underscores the necessity for educators to expand the scope of ICT use, leveraging its capabilities not only to access information but also to cultivate a more dynamic and interactive learning environment that encourages creative thinking and problem-solving skills(Ghavifekr & Rosdy, 2015). By harnessing tools such as digital forums and interactive simulations, learners can engage in meaningful discussions that not only enhance their understanding but also foster a sense of community within the classroom setting(Phanden et al., 2020). The approach of a more technology learning environment aligns with the evolving educational landscape where interactivity and multimodal communication are paramount; research indicates that students benefit significantly from environments that encourage them to see, hear, and do simultaneously, thus retaining more information. Moreover, research findings on the use of Virtual Reality (VR) in STEM education clearly indicate that teachers who are well-equipped and confident with VR technology view it as a valuable tool for enhancing students'

understanding of complex scientific concepts (Coban, 2022). This study underscores that VR not only enriches the learning experience but also empowers students to visualize and grasp abstract ideas that might otherwise be difficult to comprehend through traditional teaching methods. Furthermore, embracing ICT technologies allows for personalized learning experiences tailored to individual needs, ultimately preparing students for the complexities of modern professional environments. Hence, addressing the gap to expand the use of ICT such as IoT and simulators in the study presents a valuable opportunity for enhancing educational outcomes in STEM teaching in TVET and preparing students for the demands of a rapidly evolving technological landscape.

The role of teacher attitudes towards ICT is critical for its effective integration. Teachers who are confident and skilled in using ICT are far more likely to implement it successfully in their classrooms. As Şenyiğit and Serin (2022) notes, a teacher's self-assessed ICT competency is a key factor in determining their level of ICT integration. Teachers who are aware of their ICT capabilities are more likely to actively use technology to create engaging and dynamic learning environments. Additionally, extrinsic factors like administrative support and professional development opportunities further complicate the relationship between teachers' attitudes and their actual use of ICT (Blackwell et al., 2014; Orakova et al., 2024). For instance, schools that provide robust training programs and a supportive environment for technology integration often see higher levels of teacher engagement with ICT(Chinge & Hamid, 2020). Conversely, in settings where resources are scarce or insufficient training is offered, even skilled teachers may become disillusioned and reluctant to incorporate technology into their teaching practices. This highlights the necessity for educational institutions to invest in technology that empower teachers through ongoing training and encouragement, fostering a culture of innovation within

classrooms(D. Hu et al., 2021; Türk et al., 2018) . This study fulfils this gap by looking at professional training that provides by TVETMARA to enhance the educators' competency using technology and pedagogical.

Despite the recognized benefits, several barriers hinder the effective integration of ICT in STEM education. A common challenge, identified by (Manzano, 2023) and supported by (Şenyiğit & Serin, 2022), is the lack of adequate infrastructure and resources. Teachers often report that inconsistent support from educational institutions limits their ability to use advanced ICT tools, resulting in a reliance on basic technologies such as projectors and computers(Saienko et al., 2020). In another study, Coban (2022) highlights specific challenges related to the use of advanced ICT tools like VR in classrooms. These challenges include the high cost of VR equipment, the need for technical support, and the lack of training for teachers. Coban's findings suggest that without proper investment and support, the integration of cutting-edge ICT tools will remain limited to a few well-resourced schools, thereby increasing educational inequalities. Thus, the reliance on basic technologies can limit the potential for innovative and interactive learning experiences. Additionally, many educators face challenges related to their own digital literacy and confidence in using advanced ICT tools. Furthermore, time constraints and curriculum pressures can make it difficult for teachers to incorporate new ICT-based approaches into their lessons. These barriers collectively contribute to a gap between the potential of ICT in STEM education and its practical implementation in classrooms. Moreover, personal barriers such as resistance to change, fear of technology, and a lack of confidence also play a significant role in limiting ICT use. Teachers who are less familiar with technology or who have had negative experiences with ICT are less likely to embrace its use in the classroom.

The integration of Information and Communication Technology (ICT) into STEM education has been widely acknowledged for its ability to enhance teaching and learning outcomes. Empirical research highlights one key theme: the positive impact of ICT on student engagement and participation. According to Cigdem (2022), the use of ICT tools, including multimedia resources, interactive simulations, and virtual labs, by teachers leads to increased student involvement. These tools not only make learning more captivating but also encourage the development of critical thinking and problem-solving skills, which are crucial in STEM disciplines.

The study aims to better understand how STEM teaching can be enhanced through ICT integration in TVETMARA. The key themes from research, such as increased student engagement and the transformative potential of tools like Virtual Reality, are highly relevant. In TVET settings, where practical skills and hands-on learning are critical, ICT tools can significantly enrich the educational experience. For instance, the use of multimedia resources, interactive simulations, and virtual labs can replicate real-world scenarios, allowing students to practice and refine their skills in a controlled, virtual environment. This is particularly important in TVETMARA, where preparing students for the workforce with practical, industry-relevant skills is a primary objective.

Moreover, the use of Virtual Reality (VR) in STEM education, as highlighted by Coban (2022), can offer immersive learning experiences that are directly applicable to TVETMARA's focus on technical education. By enabling students to interact with complex concepts in a simulated environment, VR can make abstract STEM topics more accessible and easier to understand. This hands-on, experiential learning approach can not only improve conceptual comprehension but also enhance students' problem-solving

abilities and critical thinking skills, which are vital for success in technical and vocational fields.

Hence, integrating ICT in STEM education aligns with the study's aim by promoting more effective teaching methods and improving student engagement and understanding within the TVETMARA context. The use of advanced ICT tools can help TVETMARA achieve its educational objectives by providing students with the skills and knowledge necessary to excel in their future careers.

2.7 Conceptual Framework

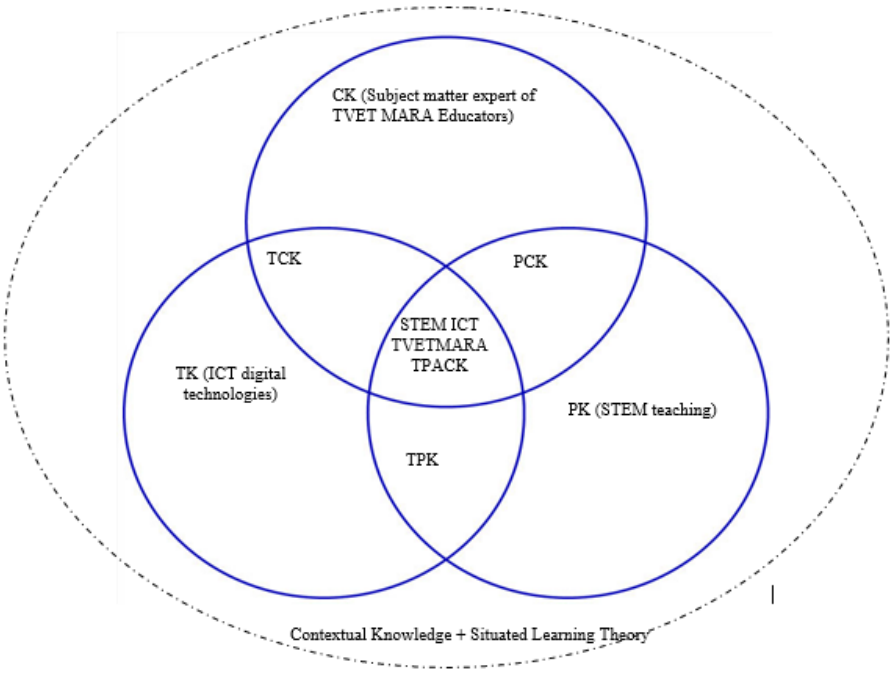


Figure 2.4: Conceptual Framework of SITI

Based on the preceding literature review (2.1 – 2.7), the conceptual framework for this study focuses on the development of a STEM ICT Teaching Inventory aimed at measuring the integration of ICT in STEM teaching among TVETMARA educators. The

framework is grounded in the Technological Pedagogical Content Knowledge (TPACK) model and the Situated Learning Theory, which together form a comprehensive foundation for understanding how ICT can be effectively integrated into educational practices, particularly within the context of TVETMARA.

The TPACK framework is central to the conceptual framework, as it integrates three key types of knowledge: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). For TVETMARA educators, Content Knowledge (CK) represents their expertise in their specific technical or vocational fields. This includes the understanding of subject matter, such as engineering, science, and other disciplines relevant to the TVETMARA curriculum. Pedagogical Knowledge (PK) refers to the educators' ability to apply appropriate teaching methods to facilitate learning. In the context of STEM teaching, PK involves strategies for teaching interdisciplinary approach in the application of workplace industry. Moreover, PK also refers to problem solving, and inquiry based to handle complex scientific and technical concepts in ways that are accessible and engaging for students. Technological Knowledge (TK) encompasses the digital tools and technologies that educators use to enhance STEM teaching, such as simulations, virtual labs, and online platforms.

The intersections of these knowledge domains form several subcomponents: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK). These components emphasize how TVETMARA educators integrate ICT into their STEM teaching and technical expertise. TPK focuses on how ICT can be used to improve STEM teaching practices, while TCK looks at how ICT can enhance the understanding and delivery of TVETMARA courses. PCK emphasizes the integration of STEM teaching and TVETMARA courses, ensuring

that the teaching strategies which includes problem based, hands-on and inquiry based align with the TVETMARA courses being taught. At the core of this integration is the TPACK framework, which reflects the blending of these three knowledge areas to support effective technology-enhanced STEM teaching practices.

Adding to the TPACK model, Situated Learning Theory plays a critical role in the conceptual framework by highlighting the importance of context in the integration ICT in STEM teaching process. This theory suggests that learning occurs most effectively when it is situated within real-world, authentic environments, such as the hands-on, practical settings of TVETMARA. Situated Learning Theory underscores the idea that TVETMARA educators should incorporate ICT tools in ways that mirror the realities of the workplace and industry, thereby enhancing the relevance of the learning experience for students. It emphasizes the social and contextual aspects of learning, where TVETMARA educators not only teach through technology but also immerse students in authentic, technology-enhanced scenarios that reflect real industry challenges.

Contextual knowledge is vital in this framework. TVETMARA educators operate in unique educational settings where factors such as resource availability, infrastructure, and student demographics influence how ICT can be integrated into teaching. The framework acknowledges that effective ICT integration requires an understanding of these contextual factors and the ability to adapt teaching practices accordingly. This includes recognizing the challenges posed by limited resources or infrastructure and finding innovative ways to incorporate technology into teaching.

Finally, the development of the STEM ICT Teaching Inventory is guided by this conceptual framework. The inventory aims to assess how well TVETMARA educators are integrating ICT into their STEM teaching by measuring their proficiency across the various

TPACK components, while also considering the influence of contextual and situated learning factors. By doing so, the inventory seeks to provide a comprehensive tool that can help improve ICT integration practices, enhance STEM education, and better prepare students for the demands of the modern workforce.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Exploratory Sequesntial Mixed Method Research Design

The study employed an exploratory sequential mixed-method research design to create the STEM ICT Teaching Inventory instrument (QUAL à Quan = instrument development). The exploratory sequential design is a mixed-method design with three distinct phases. Subsequently, researchers undertook a developmental stage to convert the qualitative results into a statistically tested methodology or tool (Creswell & Clark, 2017). This design methodology is essential for the development and validation of a new instrument that is presently absent. The researcher investigates the contextual factors that impact to the integration of ICT in STEM teaching of TVETMARA educators and identify the constructs of SITI through the exploratory and confirmatory study. Hence, it is essential to use an exploratory sequential mixed method approach to conduct a thorough investigation before utilizing SITI instrument. Additionally, the exploratory design aims to enhance understanding of the quantitative characteristics of community of practice in TVETMARA. The use of exploratory sequential mixed method design in instrument development involves three distinct stages, as Creswell and Clark (2017) outlined.

3.1.1 Rational using Exploratory Sequential Mixed Method Research Design

The exploratory sequential approach is well-suited for the goal of instrument design. Up to this date, there is no existing instrument for measuring the integration of information and communication technology (ICT) practices in STEM teaching among educators in the TVETMARA. Therefore, this research used a three-phase exploratory instrument design approach to build a survey specifically focused on STEM teaching with

ICT integration (STEM ICT Teaching Inventory). This research's primary objective was to investigate educators' experiences in the TVETMARA sector. The aim was to use the insights gained from this inquiry to create and evaluate an instrument known as the STEM ICT Teaching Inventory, specifically designed for implementation in TVETMARA institutions. Utilizing an exploratory sequential approach, the first part of the research consisted of a qualitative case study aimed at offering a comprehensive depiction and examination of the integration of information and communication technology (ICT) in the context of STEM instruction by educators in the TVETMARA. The data collection process included using multiple sources, including semi-structured interviews with ten educators from the TVETMARA program.

Additionally, data was gathered through the observation of classes and the analysis of lesson plans. Therefore, the preliminary qualitative results were used to develop the questionnaire for the subsequent survey. The survey instrument for STEM ICT Teaching was developed and administered to a substantial number of respondents based on the qualitative analysis results.

3.1.2 Philosophical Assumptions

A research paradigm, also known as a worldview, is a theoretical framework representing fundamental beliefs that guide researchers in studying and interpreting knowledge (Creswell & Plano Clark, 2017). According to Saunders et al. (2019, a researcher's paradigm encompasses four distinct strands of thinking, including epistemology (the theory of knowledge), ontology (the study of reality), axiology (the study of values), and methodology (the study itself).

It is based on the philosophical assumptions that assist researchers in their theoretical stance in deciding which methodology or research design to employ that best suit their research problems. Based on Creswell and Plano Clark (2017) four essential characteristics of worldviews in research provide the foundation of philosophical assumptions in a mixed-method practice: post-positivism, constructivism, participatory and pragmatism. However, mixed elements from various or multiple paradigms may be employed in practice for the research's compatibility. The post-positivist worldview, often linked to the quantitative approach, emphasizes the need of an unbiased and objective researcher who utilizes larger sample sizes to rigorously verify meticulously formulated hypotheses.

At the same time, a researcher with a constructivist worldview develops an understanding of the phenomena through participants' subjective views, shaped by social interaction and own personal histories. The third worldview that is also related to the qualitative approach is participatory. However, political concerns such as empowerment, patriarchy, and injustices influence a researcher with a participatory worldview.

Meanwhile, pragmatism is a worldview that emphasizes the consequences of the research and the importance of research questions. In other words, the pragmatism approach orients towards what works and practices. Hence, pragmatism is of considerable support as a stance in mixed methods research.

This study adopts two paradigms: constructivism and post-positivism. Constructivism, typically aligned with qualitative approaches, guided the initial phase of developing the STEM ICT Teaching Inventory. In this phase, understanding ICT integration practices in STEM teaching is shaped by the subjective experiences of TVETMARA educators. These educators' perceptions of ICT integration are further

informed by social interactions within the TVETMARA community of practice. An inductive approach was used, beginning with the educators' experiences to build broader themes of ICT integration practices. These themes are connected through the Technological Pedagogical Content Knowledge (TPACK) framework and Situated Learning Theory.

The second phase, which focuses on developing and validating the STEM ICT Teaching Inventory, employs the post-positivism paradigm, commonly associated with quantitative research. This phase involves an exploratory study and field testing of the instrument. A deductive approach is used to evaluate the TVETMARA educators' knowledge of ICT integration in STEM teaching, working from the predefined items in the STEM ICT Teaching Inventory to assess their practices.

3.2 Research Process

The study approach has three distinct phases: qualitative phase, integration phase of SITI development, and quantitative assessment of validity and reliability. Table 3.1 depicts the study approach, beginning with a comprehensive literature analysis to identify the existing gaps in STEM teaching. Research topics and research difficulties were derived from prior studies. Utilizing an exploratory sequential mixed methods approach, the researcher started the study with Phase 1, which included semi-structured interviews with 10 participants. Additionally, class observations were conducted with a subset of 8 participants, and 4 lesson plans were analyzed. The results of the thematic analysis indicated the presence of five distinct themes related to contextual elements in the Technological Pedagogical Content Knowledge (TPACK) of TVETMARA instructors. A generation item pool was employed in constructing the SITI, as shown by the results obtained from the qualitative investigation. In the quantitative phase, the researcher

assessed the content validity and construct validity of SITI to establish its validity and reliability.

Table 3.1: Research Process

Phase	Research Questions	Research Activities
Phase One: Qualitative Exploration	How do TVETMARA educators integrate ICT in their STEM teaching in the lens of TPACK ?	A review of related literature Study 1: Purposive sampling Semi-structured interview (N = 10) Class observations (N=8) Lesson plan analysis (N=4) Thematic analysis - 5 themes generated from qualitative findings
Phase Two: Integration phase of SITI development	What are the attributes that describe TVETMARA educators' activities in integrating ICT in STEM teaching?	Generating items pool for SITI development Situated Learning Theory to explain 5 themes as contextual factors in TPACK.
Phase Three: Quantitative phase of establishing validity and reliability of SITI	To what extend is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integrating practices in STEM teaching? Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?	Content validation by expert reviews Construct validation and reliability of SITI Study 2: Purposive sampling Exploratory study (N=162) using initial SITI Study 3: Field test (N=262) using refined SITI Factor analysis

3.3 Content of Study

The research was carried out at TVETMARA, one of Malaysia's prominent private institutions for TVET. The TVETMARA organization comprises 10 Kolej Kemahiran Tinning MARA (KKTM), MARA Japanese Industrial Institute (MJII), and 14 Institute Kemahiran MARA (IKM) institutions in various regions of Malaysia. A practical, experiential approach to training that emphasizes acquiring particular skills and competencies characterizes TVETMARA's programs. The primary instructional approach used by the institution is Work Based Learning (WBL), which integrates theoretical concepts taught in the classroom with practical application in real-world work settings. The educators at TVETMARA also use the STEM pedagogy outlined in the MARA standard textbook, known as the Standard Amalan Pendidik MARA (SPMa). Educators highly value the integration of ICT (Information and Communication Technology) in lesson planning and pedagogical approaches.

A theoretical component of 30% to 40% of the curriculum complements the engineering technology programs that TVETMARA institutions offer, with a significant portion of practical exercises ranging from 60% to 70%. Furthermore, students need to fulfill a designated duration of Industrial Training, which typically spans from 12 to 26 weeks, contingent upon the particularities of the academic program. The selection of TVETMARA as a pilot program for the integration of ICT into STEM education was based on its innovative pedagogical methods in the fields of technical and engineering.

3.4 Qualitative Phase (Initial Phase)

Given the absence of a pre-existing instrument for assessing ICT integration practices in STEM teaching by TVET educators, the researcher sought comprehensive insights into how TVET educators in TVETMARA articulated their utilisation of ICT tools

in their STEM teaching activities. The initial stage of the instrument development study involved a qualitative approach, which aimed to assist the researcher in delineating the conceptual framework of STEM teaching practices in technical and engineering that incorporate Information and Communication Technology (ICT). This was achieved through an exploration of the practices employed in TVETMARA institutions. The researcher utilised a case study approach to conduct the qualitative phase of the investigation. (Yin, 2018) posits that a qualitative case study entails the examination of a specific, present instance constrained by both time and geographic constraints. The current investigation was conducted within Technical and Vocational Education and Training for Maritime and Related Activities (TVETMARA) institutions. TVETMARA was selected as a representative example due to its status as a private Technical and Vocational Education and Training (TVET) provider in Malaysia and its possession of sufficient and easily accessible data for research.

3.4.1 Research Question

The following research question guided the qualitative phase:

1) How do TVETMARA educators integrate ICT into their STEM teaching in the lens of TPACK ?

i. What are the attributes that describe TVETMARA educators' activities in integrating ICT in STEM teaching?

3.4.2 Participation and Sampling

The qualitative case study approach employed a purposeful sampling strategy. This study chose the purposive sampling method because it enabled the researcher to recruit

participants who practice ICT integration in their STEM teaching. The sample for this study was TVETMARA educators who met the following criteria:

- Background in Technolody and Engineering
- Have attended pedagogy courses.
- Utilization of ICT (Information and Communication Technology) in teaching and learning, including software/hardware, online learning, simulators, designing tools, Microsoft, Google, etc.
- Have participated in any workshops or courses to enhance the use of technology in teaching and learning (external/internal).

The researcher sought authorization from the directors and deputy academic directors of TVETMARA to carry out the study and to get a list of TVETMARA educators who met the criteria for participation in the study. The deputy academic directors facilitated the recruitment of educators to participate in the study, who also permitted the researcher to establish contact with the participants. Upon obtaining confirmation from the educators regarding their willingness to partake, the researcher arranged an appropriate interview session date.

The participants consisted of ten TVETMARA educators selected from various engineering departments: electrical, automotive, mechanical, and civil. They were in-service TVETMARA educators from East Malaysia and West Malaysia who possessed Vocational Training Certificate (VTO) certified by the Department of Skills and Development, Ministry of Human Resources, as required by ACT 652 (NASDA). Moreover, they integrated ICT into their STEM teaching through best practices in *Standard Pendidik MARA* (SPMa). Table 3.2 reported the demographic information of the interview participants.

Table 3.2: Demographic Information of Interview Participants

Pseudonym	Age	Subject Matter Expert	Education Level	Teaching Experience
X1	36 yrs	Automotive engineering	Diploma	11 yrs
X2	43 yrs	Electrical engineering	Diploma	14 yrs
X3	37 yrs	Electrical engineering	Master (phd student)	11 yrs
X4	44 yrs	Machine building maintenance and technology	Degree	8 yrs
X5	43 yrs	Electrical and electronic engineering	Master	13 yrs
X6	39 yrs	Electrical engineering	Diploma	17 yrs
X7	44 yrs	Civil engineering	Master	17 yrs
X8	38 yrs	Electrical engineering	Master	11 yrs
X9	48 yrs	Automotive engineering	Master	20 yrs
X10	46 yrs	Mechanical engineering	Master	20 yrs

3.4.3 Data Collection

Figure 3.1 shows the step-by-step procedure for conducting data collection in the Qualitative phase. At the beginning of the study, a review of related literature was conducted to ensure that no appropriate, reliable, and valid instrument already existed for the research. Moreover, the literature review on the TPACK framework provided valuable insights that helped formulate an operational definition for integrating ICT into STEM teaching, a critical concept that this study aimed to address. Based on the findings from the literature review, the researcher adopted the study to fit the context of Standard

TVETMARA educators' practices before data collection through semi-structured interviews, class observations, and lesson plan analysis.



Figure 3.1: Step-by-step Procedure of Data Collection in Qualitative Phase

Before conducting the interviews, the researcher obtained ethical clearance (Appendix B) from TVETMARA centres via email. Once the selected participants were approved, email invitations were sent to the TVETMARA Educators. The interviews which conducted individually took place form October 2021 till February 2022. The participants were offered a choice of online interview platforms, either Microsoft Teams or Zoom. Appointments were then scheduled for those willing to participate in the research. However, before the interviews began, participants were asked to fill out consent forms that explained the purpose and benefits of their contributions to the development of the STEM ICT Teaching Inventory. Participants were also informed that the interview sessions would be audio-recorded. The interview sessions lasted two to two hours and 30 minutes. After the interview sessions ended, participants received a token of appreciation.

The researcher conducted the semi-structured open interviews using Microsoft Teams. Then, she transcribed the recordings from these sessions into Quirkos software, allowing the data to be comprehensively examined. Online interviews were conducted with ten TVETMARA educators from East Malaysia (n=6) and West Malaysia (n = 4). Microsoft Teams served as the digital canvas for capturing the sessions, where the researcher documented vital aspects reflecting the integration of ICT in STEM teaching. After each interview session, she uploaded the recordings to her Microsoft OneDrive account for transcription. Once the transcription was completed, she shared the transcripts with participants to confirm the accuracy of the interviews. After receiving confirmation from the participants, the thematic analysis of the data continued.

The researcher conducted eight class observations from the ten participants (X1, X4, X5, X6, X7, X8, X9 and X10). Two TVETMARA educators (X2 and X3) could not participate in the class observations. This was due to the changing of TVETMARA

centres. Hence, they needed to adjust to new working places, new courses to be taught, and a new group of students. Therefore, they were not adequately prepared to be observed under these circumstances. As a result, the researcher focused on the remaining participants, aiming to gather comprehensive insights into their teaching practices and classroom dynamics.

The class observations were conducted during the Covid-19 pandemic which TVETMARA had to conduct classes virtually. To facilitate this, educators used platforms such as Google Meet and Microsoft Teams for online instruction. By using these platforms, educators were able to hold live lectures and engage in interactive discussions with students through video conferencing and screen sharing. As a result, class observations were also conducted virtually via these platforms.

Participants were allowed to schedule their class observations at a time that was convenient for them, which took place between October and November 2021. However, observations were paused in December 2021 due to the semester break, but they resumed in January 2022. For participants who opted for live classroom observations, specific dates were agreed upon in advance with the researcher. Additionally, four participants provided the researcher with links to join their virtual classes in real-time, while the remaining participants chose to share recordings of their online classes instead. Each of the class observations was conducted an hour to an hour thirty minutes.

For the lesson plan analysis, four lesson plans were obtained in the *Bahagian Kemahiran Tinggi* (BKT) Cloud Ssystem (BCoS). The lesson plans were for TVETMARA Educator X1, X4, X8 and X9. Each lesson plan received was from different engineering departments (Electrical engineering, Automotive engineering, Machine building maintenance and technology and Mechanical Engineering). Moreover, during the

collection of lesson plan, the changing of system from BCoS to e-portfolio occurred. Hence the researcher did not receive permission to assess the documents. However, both the observations and lesson plan analysis assisted in understanding the teaching styles and strategies, highlighting both the strengths and challenges faced by the educators in their community of practice

3.4.4 Instrumentation

The instrumentation in qualitative phase of three instruments: interview protocol, class observation protocol and lesson plan analysis protocol.

3.4.4.1 Interview Protocol

An interview protocol was prepared to keep the researcher organized and provide a record of information (Appendix E). To define and describe TVETMARA educators' practices incorporating ICT in their STEM teaching, an interview protocol to conduct a semi-structured interview was used as an instrument to collect qualitative data in this proposed study. The interview protocol consisted of five sections with proposed 22 items.

To construct interview items for assessing Content Knowledge component of TPACK, each item aligned to TVETMARA educators' professional background, teaching experience, and field of specialization. Based on table 3.3, four items were proposed consist of the location of TVETMARA centre, years of teaching at the current centre, total years of teaching and field specification. By gathering information on duration of their involvement, it gave insight into educators' depth of experience and familiarity with the teaching environment and curriculum. Moreover, identifying areas of specialization is crucial as field of expertise to understand the content knowledge aspect of TPACK. It provides a comprehensive understanding how educators' content knowledge, aligned with experience and field specification to support the integration of ICT in STEM teaching.

Table 3.3: Mapping Interview Items with TPACK Content Knowledge

TPACK Content Knowledge	Demographic Information: Professional Background and Education
Item 1	How long have you been teaching in TVETMARA?
Item 2	How many TVETMARA centres have you taught?
Item 3	How long have you been teaching at the current centre?
Item 4	What is your field specification in TVETMARA?

To construct interview items for assessing TPACK Pedagogical Knowledge with element STEM teaching among TVETMARA participants, the items focussed on teaching methods, components of courses and interdisciplinary approaches within the teaching and learning process. Based on Table 3.4, four items adapted from Standard Pendidik MARA (SPMa) instrument were proposed to explore the pedagogical approaches and strategies used by TVETMARA educators. Item 1 was to identify the teaching strategies employed within the TVETMARA curriculum. Understanding the methods used such as lecture based teaching, hands-on practical work, problem-based learning and blended learning provide insights into pedagogical knowledge. Item 2 was used to explore the specific components such as theoretical lectures, practical sessions, workshops, group projects, assessments and the use of digital tools that cover curriculum of TVETMARA courses. Item 2 assists the understanding on how comprehensive TVETMARA courses and how educators structure their lesson to facilitate effective learning and engagement. Item 3 was to determine if TVETMARA educators employed interdisciplinary STEM teaching in the workplace problem. Item 3 reflected the participants ability to deliver the curriculum that mirrored industry practices. In Item 4, by asking participants to describe particular course

where they integrate knowledge from other fields giving concrete evidence of their innovative teaching methods.

Table 3.4: Mapping Interview Items with TPACK Pedagogical Knowledge

TPACK Pedagogical Knowledge	Teaching and Learning Process in TVETMARA
Item 1	What is the teaching method used?
Item 2	What are the teaching components in the courses in TVETMARA?
Item 3	Do teaching through combination of concepts and across curriculum occur?
Item 4	Can you describe through one of the courses that you teach where you combine other disciplines/field?

To construct interview items which mapped with TPACK components, three items adopted from TPACK interview protocol were used explore the educators' practical experiences and attitudes toward using ICT tools in STEM teaching. Based on Table 3.5, items displayed how TPACK applied in real classroom settings and for identifying areas where further support or training to optimize the use of ICT in STEM teaching. Item 1 identified the specific ICT tools included software applications (e.g., CAD, simulation software), online learning platforms (e.g., Microsoft Teams, Google Classroom), interactive whiteboards, projectors, virtual labs, and other digital resources that educators incorporate into their STEM teaching practices. Item 1 assisted the understanding on how ICT supported and enhanced the learning experience in STEM learning. Item 2 indicated participants' familiarity and comfort level with integrating ICT into their STEM teaching practices. Item 3 sought to capture the participants' perspectives and attitudes toward the

use of ICT tools in STEM teaching. It provided valuable insights into how ICT tools either to enhance or hinder the teaching and learning process.

Table 3.5: Mapping Interview Items on TPACK and STEM Teaching

TPACK	Experiences in Using ICT Tools in Your STEM Teaching
Item 1	What are the ICT tools that you use in your STEM teaching?
Item 2	How long have you been using ICT tools in your STEM teaching?
Item 3	What is your opinion on the use of ICT tools in STEM teaching?

To construct interview items which mapped with TPACK components that assessed the impact of using ICT tools on STEM teaching, two items adopted from TPACK interview protocol were used to gather insights into how educators utilized ICT to improve student learning outcomes, adapt their teaching styles, and foster more dynamic and engaging classroom environments Item 1 highlighted the specific benefits and enhancements brought about by the use of ICT tools in teaching STEM teaching.

Item 2 and item 3 aimed to capture changes in lesson planning, instructional strategies, assessment methods, classroom management, and student interaction. All items in Table 3.6 provided valuable information on the practical application of TPACK, showcasing how technological knowledge interplayed with pedagogical and content knowledge to create effective STEM teaching experiences.

Table 3.6: Mapping Interview Items with TPACK Interview Protocol

TPACK	Impact Using ICT Tools in STEM Teaching
Item 1	How does the ICT tool give positive impact toward your teaching?
Item 2	How does ICT tool influence the way you teach?
Item 3	How does the ICT tool change your pedagogical practices?

To construct interview items which mapped with TPACK components that assessed the concrete example on STEM teaching process that applied ICT tools, six items adopted from TPACK interview protocol (J. Harris et al., 2012). Based on Table 3.7, Item 1 to Item 8 provided a thorough understanding of how TVETMARA participants applied ICT tools in their STEM teaching processes. By focusing on specific examples, learning objectives, teaching methods, and contextual factors, these questions aimed to capture the practical application of TPACK. The items were designed to capture educators' experiences integrating content, pedagogy, and technology to create effective, engaging, and meaningful learning experiences for their students. They also assessed the educators' decision-making processes regarding tool selection and the influence of organizational factors on their STEM teaching practices.

Table 3.7: Mapping Interview Items with TPACK Interview Protocol (Lesson Description)

TPACK	Impact Using ICT Tools in STEM Teaching
Item 1	Choose one sub-topic/topic in your teaching that you would like to talk about. Explain the content of the sub-topic/topic and the teaching process that takes place.

Table 3.7 Continued

Item 2	Explain the learning objectives in your teaching.
Item 3	Explain the students background (such as semester and special needs in the teaching)
Item 4	Tell me the teaching process. What is the ICT tool that is used? How is the ICT tool used?
Item 5	Explain any organisational information that influence the planning or the implementation in your teaching.
Item 6	How do you choose the ICT tool for your teaching? Why does the ICT tool suit your teaching?
Item 7	How do you choose ICT tool that suit your teaching strategy? Why does the ICT tool suit your teaching strategy?
Item 8	How and why the learning objectives, teaching strategy and the application of ICT tools fulfil your teaching and learning needs?
Item 2	Explain the learning objectives in your teaching.

After the construction of items in Interview Protocol, the researched conducted the content validity. The objective of content validity in the study was to ensure that the selected items in the interview protocol adequately depicted the constructs of ICT integration activities in STEM teaching (Sánchez-Guardiola Paredes et al., 2021). The content validity of items in the Interview Protocol was conducted using Lawshe's method.

According to Lawshe (1975), researchers adopt the content validity methodology when a decision necessitates a considerable level of abstraction and comprehension, particularly in situations where multiple interpretations of a message are feasible (Lawshe, 1975). Within Lawshe's framework for content analysis, an assembly of experts initially

assesses whether the elements of the instrument are essential (E), useful yet not essential (U), or not necessary (N). The experts were contacted in person, by phone and by email. Of 11 panels, nine agreed to fill out with a return rate of 82%. Table 3.8 presents the panel experts' details. The panel of experts for the study comprises academicians and practitioners with diverse expertise and significant experience in their respective fields, contributing to the validation of the Interview Protocol. The panel includes both male and female professionals with years of experience ranging from 5 to 27 years. This diverse panel provides a balanced mix of expertise in engineering, pedagogy, curriculum design, and computer science, ensuring comprehensive evaluation and feedback for the content validation of Interview Protocol.

Table 3.8: Details of Panel Experts for Content Validation Interview Protocol

No	Initial	Expertise	Gender	Years of Experience	University
1	E1	Engineering Education	Female	16 years	TVETMARA1
2	E2	Engineering	Male	19 years	TVETMARA2
3	E3	Engineering	Male	13 years	TVETMARA3
4	E4	Curriculum and Instructional Design	Male	17 years	PU1
5	E5	Instructions/Pedagogy/Cognitive Development	Male	16 years	PU2
6	E6	Engineering	Female	7 years	PU3
7	E7	Engineering -ACADEMIC DEPUTY DIRECTOR	Male	27 years	TVETMARA4
8	E8	Computer Science	Female	20 years	TVETMARA5
9	E9	Engineering	Male	5 years	TVETMARA6

Microsoft Excel was used to analyze and calculate CVR (Content Validity Ratio) for the panel members. There were 22 items in the interview protocol. Based on nine experts, the minimum value of CVR is 75%. Based on the content validation analysis, the interview protocol for the study initially consisted of 22 proposed items. 8 items were accepted (A1, A4, B1, C1, D1, D3, E4, E8) and 5 items were rejected (A1,A3,D2,E3,E7). Based on experts' feedback, nine items were refined (B2,B3,B4,C2,C3,E1,E2,E5,E6) in the Interview Protocol. Table 3.9 shows nine items that were refined. The Content Validation Index (CV1) for the interview protocol was 0.96 . This implies the interview protocol had high level of content validity with 96% of the items were rated as relevant by the experts.

Table 3.9: Refined Items in Interview Protocol

Items	Initial Item	Refined Item
B2	What are the teaching components in the courses in MARA TVET?	What are the elements that are emphasized in teaching and learning in TVET MARA?
B3	Do teaching through combination of concepts and across curriculum occur?	Is STEM teaching being empowered in TVET MARA?
B4	Can you describe through one of the courses that you teach where you combine other disciplines/fields?	How do you combine a course that you teach with other disciplines/fields?
C2	How long have you been using ICT tools in your STEM teaching?	When did you start using ICT tools in STEM teaching?
C3	What is your opinion on the use of ICT tools in STEM teaching?	What do you think of using ICT in STEM teaching?
E1	Choose one sub-topic/topic in your teaching that you would like to talk about. Explain the content of the sub-topic/topic and the teaching process that takes place.	Choose one sub-topic/topic where you integrate ICT in your teaching . Explain the content of the sub-topic/topic and the teaching process that takes place.

Table 3.9 Continued

E2	Explain the learning objectives in your teaching.	What are your learning objectives ?
E5	Explain any organizational information that influence the planning or the implementation in your teaching.	What are the information that are given by TVET MARA influence the implementation of your teaching and learning process?
E6	How do you choose the ICT tool for your teaching? Why does the ICT tool suit your teaching?	What are the criteria in selecting ICT tools in your teaching? How do you know which ICT tools is appropriate to use?

Table 3.9 displays refinements of nine items. The refinements aimed to enhance the clarity, specificity, and focus of the interview items. Hence, the items generated more precise, actionable responses from participants, making it easier to analyze and draw meaningful conclusions about the use of ICT tools and teaching strategies in TVET MARA. The refined questions also aligned closely with the research objectives by focusing on specific aspects of teaching and learning, such as the integration of ICT, interdisciplinary approaches, and the influence of organizational factors.

Item B2 : The refined item shifted from a broad inquiry about teaching components to a more focused question on specific elements emphasized, which included practical skills, theoretical knowledge, or hands-on experience, providing more targeted insights.

Item B3 : This refinement made the item more specific by focusing on the empowerment of STEM teaching, seeking to understand institutional support and

emphasis on interdisciplinary approach of STEM teaching rather than just the occurrence of cross-curricular teaching.

Item B4: The refined version required for the method or approach used to integrate different disciplines, which provided clearer, more actionable insights into interdisciplinary teaching strategies.

Item C2 : The refined item required for a specific starting point, which helped in understanding the timeline of ICT adoption in the participant's teaching practice, rather than the duration.

Item C3 : The refined item is rephrased to be more conversational, but it retained the focus on gathering personal perspectives on ICT use in STEM teaching.

Item E1 : The refinement narrowed the focus to sub-topics where ICT was integrated, aiming to explore specific examples of ICT use in teaching.

Item E2 : The refined version simplified the item while keeping it open-ended, encouraging participants to specify their objectives clearly.

Item E5 : The refined item focused on specific information provided by TVET MARA, seeking to understand how institutional guidelines or directives influence teaching practices.

Item E6: The refinement aimed to gather detailed information on the selection criteria and decision-making processes regarding ICT tools, emphasizing suitability and appropriateness for teaching contexts.

At the beginning of the interview session, icebreaking questions were asked to create rapport between the researcher and the interviewee. The participants were requested to introduce themselves by describing their profession in TVETMARA. Then, a central question was imposed on how TVETMARA Educators conducted their STEM teaching using ICT tools. The interviewer asked the participants to describe a STEM lesson where they incorporated ICT tools. Probing questions such as why a particular ICT tool was used and how it fit in with students' STEM learning drew out extensive information on identifying and defining incorporating ICT efficiently in STEM. The interviewer asked participants to conclude by suggesting how to improve MARA TVET Educators' teaching practices using ICT.

Table 3.10 provides a summary of the content validation of expert evaluation of interview items used to assess various aspects of STEM teaching within the TVETMARA system. The Content Validation Ratio (CVR) is a numerical value ranging from -1 to +1 that indicates the validity of each item based on expert consensus. A positive CVR closer to +1 suggests high agreement among experts on the relevance of an item, whereas a negative CVR or one close to zero indicates disagreement or lesser relevance. For example, Item A1 ("How long have you been teaching in MARA TVET?") received a CVR of 1, indicating unanimous agreement on its validity. Conversely, Item A3 ("How long have you been teaching at the current center?") received a CVR of -0.11, suggesting it may not be considered relevant by the expert panel.

Based on the CVR scores, the table includes decisions to either accept, refine, or reject each item. Items with high CVR scores (e.g., 1 or 0.78) were accepted (Lawshe, 1975). Items with lower CVR scores (e.g., -0.11) were considered for refinement or rejection. For example, Item E7 ("How do you choose ICT tools that suit your teaching

strategy? Why does the ICT tool suit your teaching strategy?") received a CVR of 0.33 and was marked for refinement, indicating that experts believe the question may need to be adjusted for clarity or relevance.

The overall CVI of 0.96 indicated that the interview protocol was well-designed and that most items effectively captured relevant information related to STEM teaching, ICT tool usage, and the integration of pedagogical strategies in the TVETMARA system. The evaluation process and results for the interview items, provided a clear indication of which items were well-supported by expert consensus and which required further refinement. The use of CVR ensured a rigorous validation process, enhancing the reliability and relevance of the interview protocol for studying STEM teaching in the TVETMARA context.

3.4.4.2 Class Observation Instrument

The researcher adapted class observation protocol from TPACK class observation check list (Gomes, 2016) and SPMa instrument (Appendix F). The class observation protocol was organized corresponded to the elements in TPACK. It is designed to measure the integration of ICT in STEM teaching within TVET by utilizing the TPACK framework. The checklist evaluates key aspects of teaching by focusing on seven components. The first component, Technological Knowledge (TK), assesses the teacher's ability to use essential ICT tools for the lesson, support instructional strategies with ICT, and demonstrate competence in using the technology without difficulties. The Content Knowledge (CK) component looks at the teacher’s mastery of the subject matter, ensuring that they present relevant and accurate information while using diverse examples and assigning tasks to reinforce the lesson.

Pedagogical Knowledge (PK) is also assessed, emphasizing the teacher's application of appropriate pedagogical approaches for STEM, consideration of diverse learning styles, and effective structuring of lessons that incorporate creative and critical thinking. Educators' ability to align teaching strategies and the learning outcomes in the lesson is evaluated in Pedagogical Content Knowledge (PCK). Technological Content Knowledge (TCK) focuses on how the teacher uses ICT to explain complex ideas and encourage self-discovery and exploration by students. The checklist also examines Technological Pedagogical Knowledge (TPK), ensuring that ICT is used to engage students, foster collaboration, and adapt to individual learning paces, as well as for project-based learning (PBL). Finally, the TPACK component assesses the overall integration of content, ICT, and STEM teaching, measuring how effectively ICT supports learning, collaboration, and content manipulation. This comprehensive checklist provides a systematic way to observe and evaluate the integration of ICT in STEM education within TVET contexts. Consequently, while engaged in the process of note-taking during observations, the researcher coded the acquired information according to the established components of. The data from the class observation field became the supporting evidence of TPACK elements from the interview sessions.

Table 3.10: Content Validation Ratio (CVR) of Panel Experts for Interview Protocol

Bil	Section	Item	CVR	Accept	Refine	Reject
A	*Demographic information : Professional background and education – CONTENT KNOWLEDGE*	*A1) How long have you been teaching in MARA TVET?*	1	√		
		A2) How many MARA TVET centers have you taught?	0.56			√
		A3) How long have you been teaching at the current center?	-0.11			√
		A4) What is your field specification in MARA TVET?	1	√		
B	*Teaching and learning process in MARA TVET – PEDAGOGICAL KNOWLEDGE*	*B1) What is the teaching method used? (etc OBE, pbl, hands-on)*	1	√		
		B2) What are the teaching components in the courses in MARA TVET?	0.78		√	
		B3) Do teaching through combination of concepts and across curriculum occur?	0.78		√	
		B4) Can you describe through one of the courses that you teach where you combine other disciplines/fields?	0.78		√	

Table 3.10 Continued

C	*Experiences in using ICT tools in your STEM teaching – TECHNOLOGY PEDAGOGICAL KNOWLEDGE*	*C1) What are the ICT tools that you use in your STEM teaching?*	1	√		
		C2) How long have you been using ICT tools in your STEM teaching?	0.78		√	
		C3) What is your opinion on the use of ICT tools in STEM teaching?	0.78		√	
D	*Impact using ICT tools in STEM teaching – TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE*	*D1)How does the ICT tool give positive impact toward your teaching?*	1	√		
		D2)How does the ICT tool influence the way you teach?	0.56			√
		D3)How does the ICT tool change your pedagogical practices?	1	√		
E	*STEM teaching process where applying ICT tools using specific example – TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE*	*E1) Choose one sub-topic/topic in your teaching that you would like to talk about. Explain the content of the sub-topic/topic and the teaching process that takes place.*	0.78		√	
		E2) Explain the learning objectives in your teaching.	0.78		√	
		E3) Explain the students background (such as semester and special needs in the teaching).	-0.11			√

Table 3.10 Continued

E	*STEM teaching process where applying ICT tools using specific example – TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE*	*E4) Tell me the teaching process. What is the ICT tool that is used? How is the ICT tool used?*	1	√		
		E5)Explain any organizational information that influence the planning or the implementation in your teaching.	0.78		√	
		E6) How do you choose the ICT tool for your teaching? Why does the ICT tool suit your teaching?	0.78		√	
		E7) How do you choose ICT tool that suit your teaching strategy? Why does the ICT tool suit your teaching strategy?	0.33			√
		E8) How and why the learning objectives, teaching strategy and the application of ICT tools fulfill your teaching and learning needs?	1	√		
		E4) Tell me the teaching process. What is the ICT tool that is used? How is the ICT tool used?	1	√		

Table 3.10 Continued

E	*STEM teaching process where applying ICT tools using specific example – TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE*	*E5) Explain any organizational information that influence the planning or the implementation in your teaching.*	0.78		√	
		E6) How do you choose the ICT tool for your teaching? Why does the ICT tool suit your teaching?	0.78		√	

CVI = 0.96 (22 ITEMS , 17 ACCEPTED)

3.4.4.3 Lesson Plan Analysis Protocol

The researcher used TPACK assessment rubric (Appendix G) to analyze four lesson plans (Hofer et al., 2011). TPACK Lesson Plan assessment rubric assesses four key areas: curriculum alignment, instructional strategies, technology selection, and the overall fit between content, pedagogy, and technology. In curriculum alignment, the rubric examines how well the ICT chosen to align with the TVETMARA curriculum goals, ensuring that participants directly support the Programme educational objectives. Besides that, Curriculum goals section also evaluates how effectively ICT enhances STEM teaching, determining either they facilitate or hinder teaching and learning experience. Furthermore, the rubric assesses the appropriateness of the selected ICT in relation to both the TVETMARA curriculum goals and the instructional methods of STEM teaching. Finally, it evaluates the overall cohesion between the technical and engineering TVETMARA content, STEM teaching, and ICT, ensuring that the three elements fit together within the educational plan. This structured approach helps the researcher reflect on the lesson plans of the participants in planning their STEM teaching in TVETMARA. Each item was rated from 0 (not present) and 1(present).

3.4.5 Data Analysis

In the qualitative phase, the researcher began analyzing the data from the semi-structured open interview (Appendix using Braun and Clarke (2006) approach to Thematic analysis. According to Braun & Clarke (2006), there are six phases of Thematic analysis:

1. Familiarize with data: In the first step to familiarize herself with data, the researcher conducted and transcribed interviews herself. It allowed the researcher to reflect and be familiarized with the words used by the participants when they described how they conducted their STEM teaching with the inclusion of ICT.

2. Generate initial codes: Both inductive and deductive coding were integrated with the generating codes phase. Using Quirkos software, ‘toggle notes’ were used on transcriptions before assigning codes and themes. For example, using TPACK as the basis of investigation for the conceptual framework codes ICT selection based on curriculum and teaching strategies become the indicators of ICT integration practices (Appendix H). However, taking the participants’ language, such as ‘practical class’, served as inductive coding.



Figure 3.2: Coding from Quirkos Output

3. Search for themes: In this step, the researcher identified patterns of shared meaning across the coded data (Appendix H). For example, codes simulator, upgraded drawing, and advanced technology categorized under the theme ‘ICT selected is aligned with courses outcomes taught’.

4. Review themes: To check if the themes capture the essence of the coded data, the researcher incorporated and reflected on the literature.

5, Define and name themes: Based on step 4, the researcher assigned informative and engaging names to each theme.

6. Produce report: Literature was used to confirm the final analysis by selecting excerpts from the participants and the researcher’s interpretation.

3.5 Exploratory Sequential Mixed Method Instrument Development (Mixing Phase)

In the exploratory sequential mixed method instrument development phase where the study's integration occurs, the main activity is generating items pool. Item generation is concerned with determining a set of items representing the conceptual domain of the construct (DeVellis, 2016; MacKenzie et al., 2011). Therefore, the STEM ICT Teaching Inventory (SITI) instrument items was selected based on the instrument's purpose to measure ICT integration practices in STEM teaching of TVETMARA educators. Moreover, to avoid indicators of deficient items and provide good internal consistency, at the initial point in a development phase, there was a need to well written the construct's definition with a large number of items in the STEM ICT Teaching Inventory (SITI) survey. Other than that, to avoid ambiguity in items, STEM ICT Teaching Inventory (SITI) items wordings should be concise and straightforward. Since the Likert scale was be employed as the items responses format, the STEM ICT Teaching Inventory (SITI)

survey's items was presented in a declarative sentence indicating a carrying degree of agreements.

The design and development phase continued by conducting content validation and pre-testing of STEM ICT Teaching Inventory (SITI).

3.6 Quantitative Phase (Validation and Realibility Phase)

The quantitative phase used a survey approach. A survey is a quantitative method in which the researcher administers a questionnaire to a sample to describe the population's characteristics (attitudes, opinions, behaviours, and experiences). Accuracy and consistency of information from a questionnaire or survey are essential for the instruments' validity and reliability. The issues of reliability and validity of the instruments utilised in a study influence the decision to accept its findings. Validity refers to the extent to which an idea is accurately assessed or measured, whereas reliability pertains to the consistency and precision of the measuring instrument or technology. This study focused on content validity, construct validity and internal consistency reliability.

3.6.1 Research Questions

1) To what extent is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integration practices in STEM teaching?

2) Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?

3.6.2 Participants and Sampling

3.6.2.1 Field Study

The quantitative phase consisted of Field Study 1 and Field Study 2. Both had a different set of participants. Field Study 1 was conducted to obtain information on deficiencies and suggestions to improve the instrument by examining measurement model type, internal consistency reliability and scale dimensionality. One hundred sixty-two educators teaching in TVETMARA institutions were selected through random sampling for Field Study 1. As in Field Study 2, new empirical data was collected from 265 educators in TVETMARA who attended a 1-day training on 21st Century Pedagogy to examine construct and internal validity. Both groups were selected due to their pedagogical role in ICT integration practices, where they practised problem-based learning, project-based learning and hands-on teaching and learning of TVET. Hence, regardless of their geographical locations, TVETMARA educators in TVETMARA practice standard pedagogical ICT integration.

Table 3.11: Demographic Analysis of Field Study 1 Participants

Gender	Frequency	Percent
Male	107	66.0
Female	55	34.0
Total	**162**	**100.0**

Table 3.12: Age of Field Study 1 Participants

Age	Frequency	Percent
Less than 30 years	5	3.1
Between 30 years and 40 years	81	50.0
Between 41 years and 51 years	65	40.1
More than 51 years	11	6.8
Total	**162**	**100.0**

Table 3.13: Education Background of Field Study 1 Participants

Education	Frequency	Percent
Certificate	3	1.9
Diploma	50	30.9
Degree	54	33.3
Master	52	32.1
PhD	3	1.9
Total	**162**	**100.0**

Table 3.14: Teaching Experience of Field Study 1 Participants

Teaching Experience	Frequency	Percent
Less than 5 years	24	14.8
Between 5 years and 10 years	29	17.9
Between 11 years and 15 years	42	25.9
Between 16 years and 20 years	44	27.2
More than 20 years	23	14.2
Total	**162**	**100.0**

Table 3.15: Industrial Experience of Field Study 1 Participants

Teaching Experience	Frequency	Percent
Less than 5 years	28	17.3
Between 5 years and 10 years	110	67.9
Between 11 years and 15 years	19	11.7
Between 16 years and 20 years	4	2.5
More than 20 years	1	6
Total	**162**	**100.0**

Table 3.11 provides a demographic analysis of the participants involved in Field Study 1, focusing on key characteristics such as gender, age, education background, teaching experience, and industrial experience. The total number of participants is 162 with 107 (66%) are male, while 55 (34%) are female. This indicates a higher representation of male participants in the study, reflecting the gender distribution common in technical and vocational education settings. The majority of participants (81 individuals or 50%) fall within the 30-40 age group, indicating that mid-career professionals form the largest segment of the sample. A significant portion (40.1%) are between 41 and 51 years of age, while 6.8% are over 51 years old. Only 3.1% of the participants are under 30 years of age, reflecting a relatively experienced cohort. The educational qualifications of the participants vary, with the largest group holding degrees (54 participants or 33.3%). This is closely followed by participants with master's degrees, comprising 52 individuals (32.1%). Those with diplomas account for 30.9% of the sample, while only a small number of participants hold PhDs or certificates (1.9% each).

The participants have a wide range of teaching experience. The largest group, 44 participants (27.2%), have between 16 and 20 years of teaching experience, followed by 42 participants (25.9%) with 11 to 15 years of experience. Those with less than 5 years of experience represent 14.8% of the sample, while those with over 20 years of teaching experience constitute 14.2%, indicating a diverse range of teaching expertise across the group. Most participants have substantial industrial experience, with 110 participants (67.9%) having 5 to 10 years of industrial exposure. A smaller portion (17.3%) have less than 5 years of industry experience, and only 11.7% have worked in the industry for 11 to 15 years. A very small number have more than 16 years of industrial experience, with only one participant (0.6%) having over 20 years of industrial involvement. This shows that

while the participants are largely experienced in both teaching and industry, the majority have more teaching experience than industrial experience.

Table 3.16: Demographic Analysis of Field Study 2 Participants

Gender	Frequency	Percent
Male	183	69.1
Female	82	30.9
Total	**265**	**100.0**

Table 3.17: Age of Field Study 2 Participants

Age	Frequency	Percent
Less than 30 years	10	3.8
Between 30 years and 40 years	137	51.7
Between 41 years and 51 years	107	40.4
More than 51 years	11	4.2
Total	**265**	**100.0**

Table 3.18: Education Background of Field Study 2 Participants

Education	Frequency	Percent
Certificate	16	6.0
Diploma	90	34.0
Degree	68	25.7
Master	85	32.1
PhD	6	2.3
Total	**265**	**100.0**

Table 3.19: Teaching Experience of Field Study 2 Participants

Teaching Experience	Frequency	Percent
Less than 5 years	33	12.5
Between 5 years and 10 years	55	20.8
Between 11 years and 15 years	90	34.0
Between 16 years and 20 years	52	19.6
More than 20 years	35	13.2
Total	**265**	**100.0**

Table 3.20: Industrial Experience of Field Study 2 Participants

Teaching Experience	Frequency	Percent
Less than 5 years	37	14.0
Between 5 years and 10 years	183	69.1
Between 11 years and 15 years	40	15.1
Between 16 years and 20 years	3	1.1
More than 20 years	2	0.8
Total	**265**	**100.0**

Table 3.16 presents a demographic analysis of the participants involved in Field Study 2, which includes a total of 265 participants. The data provides insight into various demographic characteristics, including gender, age, education background, teaching experience, and industrial experience.

Out of the 265 participants, 183 (69.1%) are male, while 82 (30.9%) are female. In terms of age, the majority of participants (137 individuals or 51.7%) are between 30 and 40 years old, indicating that a significant portion of the sample consists of mid-career professionals. The next largest group, representing 40.4% (107 participants), are between 41 and 51 years old. A smaller percentage of participants are over 51 years old (4.2%), and

only 3.8% are under 30 years old, suggesting that the participants are generally experienced professionals. In terms of educational background, the participants display a wide range of educational qualifications. The largest group holds diplomas, with 90 individuals (34.0%). This is followed by those with master's degrees, comprising 85 participants (32.1%), and those with bachelor's degrees (68 participants, 25.7%). A smaller number of participants hold certificates (16 participants, 6.0%) and PhDs (6 participants, 2.3%), indicating a diverse range of educational attainment levels among the participants.

Participants' teaching experience also varies considerably. The largest group (90 participants, 34.0%) has between 11 and 15 years of teaching experience, followed by those with 5 to 10 years of experience (55 participants, 20.8%). Additionally, 19.6% (52 participants) have 16 to 20 years of experience, while 13.2% have over 20 years of teaching experience. A smaller group (12.5%) has less than 5 years of teaching experience, showing that the participants possess a broad spectrum of teaching expertise. Contrary to Industrial Experience of participants, majority of participants (183 individuals or 69.1%) have between 5 and 10 years of industrial experience, indicating substantial practical exposure to industry-related activities. A smaller portion of the participants (15.1%) have 11 to 15 years of industrial experience, while 14.0% have less than 5 years of industry experience. Very few participants (1.1% and 0.8%) have more than 16 years of industrial experience, suggesting that most participants are relatively mid-career professionals when it comes to industrial exposure.

In summary, the demographic data in Table 3.12 reveals that the participants of Field Study 2 represent a broad mix of gender, age groups, educational backgrounds, and professional experiences. This diversity in demographics provides a comprehensive foundation for analyzing ICT integration practices in STEM teaching within the

TVETMARA context, especially with regard to teaching and industry experience, which are crucial for understanding the practical application of ICT in education.

3.6.3 Data Collection

Data collection in the quantitative phase was obtained through a (questionnaire) survey study. The STEM ICT Teaching Inventory was developed based on the initial qualitative findings. A letter of approval was written to the MARA organization to obtain permission to administer Field Study 1 and Field Study 2. Once permission was granted, an informed consent form for the field study was written and distributed to TVETMARA centres in Malaysia. The revised STEM ICT Teaching Inventory instrument was administered with an email request for participation and an accompanying link for the online STEM ICT Teaching Inventory instrument. After Field Study 1, the STEM ICT Teaching Inventory instrument was revised. Field study 2 was conducted during an online workshop. After obtaining permission from the workshop organiser, the researcher distributed a link to the online STEM ICT Teaching Inventory instrument. The overall response rate was 58%, 262 out of 450.

3.6.4 Data Analysis

3.6.4.1 Normality of Data

Mean, standard deviation, kurtosis, and data skewness were examined in discriminant analysis. This was to test the normality of the data. A 100% normal distribution has skewness and a kurtosis value of zero (0). The measure of skewness is used to represent the degree of distribution symmetry.

A positive value shows a positively skewed graph, whereas a negative value shows a negative skew. Kurtosis provides information on the 'peakedness' of the distribution. A positive kurtosis value shows a high distribution curve (leptokurtic), and a negative

kurtosis value shows a low distribution curve (platykurtic). The skewness and kurtosis values should be in the range of -1.96 to + 1.96 for the data to be normally distributed. Analyzing the extracted histogram of the collected data is not normally distributed. In this case, the distribution of data from the STEM ICT Teaching Inventory is normal because the skewness value range

3.6.4.2 Releability Analysis

Reliability analysis is a statistical technique to assess the consistency, stability, and precision of measurements or items within a measurement instrument (Kimberlin & Winterstein, 2008). In other words, it helps determine how well a set of items or questions in a survey, test, questionnaire, or other measurement instrument consistently measures the same underlying construct or trait.

In instrument development, Reliability analysis is vital to ensuring that a reliable instrument produces consistent results over repeated measurements or across different parts of the instrument. An unreliable instrument can lead to varying and inconsistent results, making it difficult to draw accurate conclusions. Moreover, Reliability is a prerequisite for validity. An instrument must be reliable to be valid. Validity refers to the degree to which a given measuring device accurately represents the objective concept.

Reliability analysis helps establish a foundation for further validity testing. There are several methods to assess Reliability, which include :

i. Cronbach's Alpha :Cronbach's Alpha is a common internal consistency measure that measures how strongly items in a collection are related to one another.

ii. Test-Retest Reliability: The stability of an instrument is assessed by examining the scores obtained from the same individuals at two distinct time points.

iii. Inter-Rater Reliability: Measures the agreement among multiple raters or observers when using the same instrument.

iv. Split-Half Reliability: Divide the items in an instrument into two halves and compare the scores to assess the consistency between the halves.

v. McDonald's Omega (ω): A measure of Reliability that is commonly used as part of reliability analysis. It is an alternative to Cronbach's Alpha and is designed to assess the internal consistency of a set of items in a measurement instrument, such as a questionnaire or survey. McDonald's Omega is particularly useful when dealing with multidimensional constructs or situations where items might have different levels of factor loading (the extent to which an item reflects a latent factor or construct). Unlike Cronbach's Alpha, McDonald's Omega considers factor loadings and item variances when estimating Reliability, making it a more robust measure for complex factor structures(Mikkonen et al., 2022)

In this study, reliability analysis was conducted using Cronbach's Alpha to assess how the items in each factor correlate. The study was also conducted using McDonald's Omega since the STEM (ICT) Teaching Inventory is a multidimensional construct where factor ICT selection, Pedagogical Practices and Lesson preparation are related but distinct.

Structural Equation Modeling (SEM), a second-generation approach, enables researchers to effectively incorporate latent variables by utilizing proxy indicators (Hair, Hult, et al., 2017)Moreover, SEM allows researchers to assess the overall fit of a model. The principal utilization of covariance-based structural equation modeling (CB-SEM) is in the examination and evaluation of hypotheses. The evaluation of the ability of a theoretical

model to estimate the covariance matrix for sample data is conducted. Therefore, the researcher used CB-SEM to conduct confirmatory analysis using SPSS AMOS. Moreover, CB-SEM was a suitable data analysis for the STEM ICT Teaching Inventory with a good sample size of more than 200 participants. Since the objective of applying structural modelling is to predict and explain constructs, this is another reason CB-SEM was employed in developing and validating the STEM ICT Teaching Inventory survey instrument.

Table 3.21 reveals key indicators that help determine if the data meets the assumptions for SEM, particularly regarding normality and the suitability of results. The skewness and kurtosis values are important indicators of data normality because it influences the accuracy and validity of the model fit. Skewness measures the symmetry of the data distribution. In the table, skewness values range from -1.458 (for ICT Selection 2) to -0.026 (for Lesson 6). Most of these values are negative, indicating that the data is slightly skewed to the left. However, the values generally fall within the commonly accepted range for SEM, which is between -3 and +3 (Jaber, 2022) . This suggests that while there is some skewness in the data, it is not extreme enough to violate the assumptions of normality. Slight skewness, particularly in educational data, is quite common and often acceptable for SEM without requiring transformation (Karakaya-Ozyer & Aksu-Dunya, 2018).

Kurtosis measures the "tailedness" of the data distribution, i.e., how peaked or flat the distribution is compared to a normal distribution. The kurtosis values range from -0.745 (Lesson 5) to 3.058 (ICT Selection 2). A kurtosis value between -3 and 3 is generally considered acceptable for SEM (Aburumman et al., 2023). Here, most values are well within this range, with only a few variables (such as ICT Selection 2) having higher

kurtosis, indicating a more peaked distribution. Despite this, these values are still within the acceptable range for SEM analysis. Higher kurtosis in a few variables may slightly affect model fit but not enough to disqualify the use of SEM.

The standard deviation values across the variables show moderate variability, with some items showing more dispersion (e.g., ICT Selection 3, with a standard deviation of 1.403) and others being more consistent (e.g., ICT Selection 1, with a standard deviation of 1.016). Moderate dispersion indicates that the participants' responses were varied, but this is typically expected in education-based surveys, especially those focused on technology integration, where individuals may have different levels of familiarity and comfort.

Since the data shows acceptable skewness and kurtosis values, it suggests that the data distribution is close to normal, which is a fundamental assumption for SEM. When data meets the normality assumptions, it allows the SEM to more accurately estimate parameters and fit the model. If the data were highly skewed or kurtotic, it could lead to biased estimates or poor model fit. In this case, the moderate skewness and kurtosis indicate that the data should be suitable for SEM without major adjustments like data transformation.

Based on the skewness, kurtosis, standard deviations, and sample size, it can be concluded that the dataset is generally suitable for SEM analysis. The variables show normality within acceptable ranges, meaning that the researcher can proceed in using SEM to conduct exploratory and confirmatory study. Any minor deviations from normality are unlikely to significantly affect the results and can be handled through techniques like robust estimation methods if necessary.

Table 3.21: Normality Data Analysis

Table 3.13 Normality Data Analysis

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
ICT Selection 1	162	3.00	7.00	5.8148	1.01677	-.912	.191	.132	.379
ICT Selection 2	162	1.00	7.00	5.9074	1.03243	-1.458	.191	3.058	.379
ICT Selection 3	162	1.00	7.00	5.2593	1.40344	-.950	.191	.606	.379
ICT Selection 4	162	1.00	7.00	5.6296	1.19465	-1.130	.191	1.431	.379
ICT Selection 5	162	1.00	7.00	5.2037	1.41921	-.815	.191	.147	.379
ICT Selection 6	162	1.00	7.00	5.5000	1.20171	-.761	.191	.313	.379
ICT Selection 7	162	1.00	7.00	5.4444	1.14751	-.636	.191	.313	.379
ICT Selection 8	162	2.00	7.00	5.3580	1.11799	-.502	.191	-.497	.379
ICT Selection 9	162	3.00	7.00	5.5494	1.06353	-.742	.191	-.121	.379
ICT Selection 10	162	2.00	7.00	5.5062	1.13798	-.784	.191	.367	.379
Pedagogy1	162	3.00	7.00	5.8704	1.05229	-.871	.191	.074	.379
Pedagogy2	162	2.00	7.00	5.9198	1.03946	-1.115	.191	1.098	.379
Pedagogy3	162	1.00	7.00	5.1667	1.27688	-.625	.191	.060	.379
Pedagogy4	162	2.00	7.00	5.3457	1.15463	-.414	.191	-.438	.379
Pedagogy5	162	1.00	7.00	5.6296	1.23554	-1.023	.191	.839	.379
Pedagogy6	162	2.00	7.00	5.2222	1.26098	-.579	.191	-.140	.379
Pedagogy7	162	1.00	7.00	5.1296	1.24181	-.702	.191	.231	.379
Pedagogy8	162	2.00	7.00	5.0062	1.23860	-.349	.191	-.499	.379
Pedagogy9	162	1.00	7.00	5.3765	1.29507	-.784	.191	.683	.379
Lesson1	162	1.00	7.00	5.2407	1.21995	-.784	.191	.748	.379
Lesson2	162	1.00	7.00	4.8765	1.17302	-.318	.191	.442	.379
Lesson3	162	3.00	7.00	5.7160	1.06596	-.688	.191	-.580	.379

Table 3.21 Continued

Lesson4	162	2.00	7.00	5.2593	1.18770	-.448	.191	-.434	.379
Lesson5	162	2.00	7.00	5.1296	1.15903	-.232	.191	-.745	.379
Lesson6	162	1.00	7.00	4.7716	1.34337	-.026	.191	-.455	.379
Lesson7	162	2.00	7.00	5.3333	1.24112	-.480	.191	-.401	.379
Lesson8	162	2.00	7.00	5.2531	1.13833	-.281	.191	-.565	.379
Peer1	162	1.00	7.00	4.3704	1.31824	-.118	.191	-.212	.379
Peer2	162	2.00	7.00	5.1975	1.27001	-.396	.191	-.601	.379
Peer3	162	2.00	7.00	5.0062	1.16628	-.250	.191	-.616	.379
Peer4	162	2.00	7.00	5.2654	1.14639	-.386	.191	-.403	.379
Peer5	162	2.00	7.00	5.2778	1.16496	-.583	.191	-.145	.379
Peer6	162	2.00	7.00	5.0556	1.22728	-.413	.191	-.222	.379
Peer7	162	2.00	7.00	5.2593	1.22376	-.488	.191	-.292	.379
Organisation1	162	1.00	7.00	5.0123	1.41854	-.934	.191	.339	.379
Organisation2	162	2.00	7.00	5.0926	1.26984	-.673	.191	-.307	.379
Organisation3	162	2.00	7.00	4.8704	1.34275	-.493	.191	-.563	.379
Organisation4	162	1.00	7.00	4.8765	1.45647	-.638	.191	-.251	.379
Organisation5	162	1.00	7.00	4.6543	1.44601	-.599	.191	.025	.379
Organisation6	162	1.00	7.00	5.0432	1.24785	-.626	.191	.309	.379
Organsation7	162	1.0	7.0	5.000	1.3188	-.757	.191	.200	.379
Organisation8	162	1.00	7.00	4.9568	1.34372	-.651	.191	-.034	.379
Valid N (listwise)	162								

CHAPTER 4

RESULTS

4.1 Introduction

The study was conducted to answer three research questions and one sub question for Research Question 1:

1) How do TVETMARA educators integrate ICT in their STEM teaching in the lens of TPACK?

    a. What are the attributes that describe TVETMARA educators' activities in integrating ICT in STEM teaching?

2) To what extent is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integration practices in STEM teaching?

3) Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?

This chapter examines results for Phase 1: Qualitative phase, Phase 2: Generating items and Phase 3: Quantitative Evaluation and Validation. The qualitative findings describe how TVETMARA educators integrate ICT into their STEM teaching. The STEM ICT Teaching Inventory was developed using qualitative findings to measure TVETMARA educators' pedagogical practices when incorporating ICT in STEM teaching. This chapter describes in detail the qualitative and quantitative methods, such as expert evaluations and factor analysis, that were utilized to develop the instrument. The final

section is the results of the structural equation modeling analysis of the STEM ICT Teaching Inventory.

The qualitative data were thoroughly explored through interview transcripts, class observation field notes and analytical notes during data collection. Then, the data were coded, and themes were generated (Plano Clark & Creswell, 2015). Data triangulation was studied through interviews, class observation and lesson plan analysis. The psychometric aspects of the quantitative data were examined using two statistical software tools, IBM SPSS Statistics 22 and IBM SPSS AMOS 26.

4.2 Qualitative Results (Phase 1)



Figure 4.1: Themes from Qualitative Findings

The TPACK framework guides the entire study and informs the coding and analysis of themes to develop the STEM ICT Teaching Inventory. Five themes on the

practices of ICT integration in STEM teaching among TVETMARA educators were generated after analysing and triangulating multiple data sources in the case study, including ten individual interviews, class observations and lesson plan analysis. The five themes are: (1) ICT selection, (2) Ogranisation support , (3) Peer collaboration , (4) Pedagogical practices, and (5) Lesson preparations.

4.2.1 Theme 1: Criteria for ICT Selection

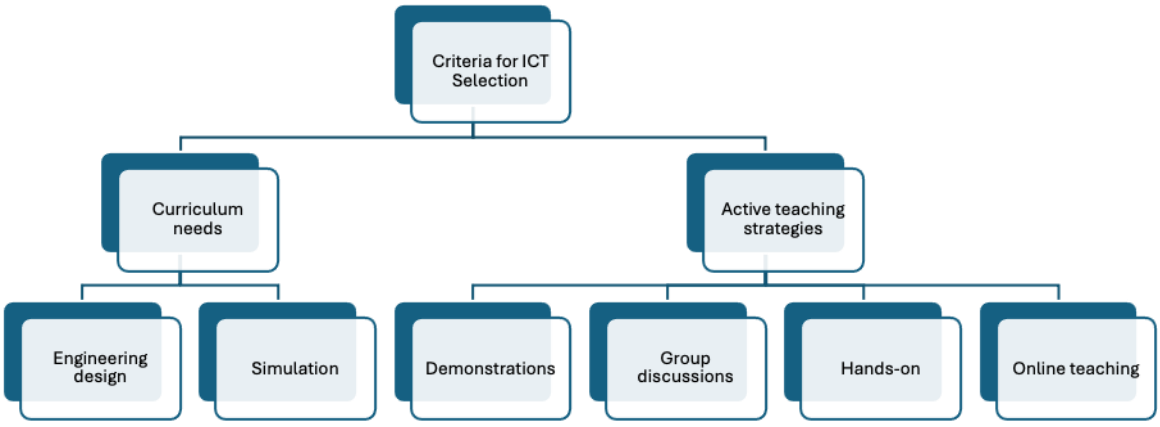


Figure 4.2: Concept Map for Theme 1

Two discrete aspects have emerged based on the qualitative findings of Theme 1 Criteria for ICT Selection. Firstly, TVET MARA teachers tend to select ICT tools based on the needs of their curriculum, which are designed to fit into the scope of industrial-based recognition and match STEM teaching. The syllabus and learning outcomes in TVETMARA courses cover engineering design and simulation modeling. In engineering design, engineering drawing is a fundamental tool in designing complex engineering projects. It provides accurate and detailed plans for a building or structure.

Additionally, engineering drawings become visual guides for engineers to ensure that components are manufactured precisely. Furthermore, engineering drawings help identify errors early to avoid costly revisions. Therefore, engineering drawing is a critical phase in forming future engineers. With the advancement of IR 4.0, ICT plays a crucial role in engineering drawing by improving the efficiency of computer-aided design systems. With the help of software like AutoCAD, computer-aided design systems are used in the process of design and technological preparation of production(Gilmanova, 2020) . In the interview with TVETMARA educators, engineering drawing is highlighted as one of the main courses taught in various technical engineering departments. For example, in automotive engineering, a TVETMARA educator (X1) shared that :

> For semester one students, I am teaching them to use AutoCAD software for basic engineering drawings since they are still learning engineering concepts. The name of the course is Engineering Drawing, which helps students produce and interpret production drawings based on standard specifications. Semester 3 students are taught inventor software to upgrade their two-dimensional and three-dimensional drawings.
>
> (X1)

Another TVETMARA educator (X4) supports the importance of engineering drawings in construction. She demonstrated it in her online CAD1 class. In her interview, she commented that:

> Computer-aided design (CAD) is taught not only to semester one students but also to semester two and semester three students. There is only a difference in the syllabus. However, it is still using the same software. In semester 2, the design will

be related to 'fit limit and tolerance'. The concept of CAD in geometric construction will involve drawing with dimensions. In semester 1, the students will apply basic dimensions, fit limits, and tolerance to their drawings. Later, they will need to apply their understanding in practical workshops. In semester 5, Kartia software is used to analyse drawings. Students need to know that they can analyse their designs when placing pressure. For example, the ability to withstand loads and which parts will cause damage (cracks) can be analysed with pressure.

(X4)

TVETMARA educator X6, who has experience teaching mechanical and electrical engineering, illustrates the difference between applying AutoCAD in both fields. He said that:

Mechanical engineering uses AutoCAD for design. I taught Marine students in the TVETMARA centre using AutoCAD to draw isometric and two-dimensional displays with the top and back. It is more complicated in the Mechanical field and involves hidden dimensions than in the Electrical field, which is more related to house plans and schematic drawings.

(X6)

Excerpts from interviews with X1, X4 and X6 reveal that the TVETMARA syllabus provides guidance on software selection for engineering drawing classes. Specifically, using AutoCAD as a teaching aid helps to visualise designs and simplify the construction of complex structures. AutoCAD's modelling capabilities produce precise printouts that enhance accuracy and serve as valuable communication tools in the classroom. These printouts provide clear visuals and concise information to enable

technician trainees to understand what needs to be done and how it should be done. Hence, using AutoCAD as an ICT tool in STEM teaching enhances the learning experience of TVETMARA students.

In the engineering industry, simulators are a crucial tool for experimentation. As engineers strive to propose new ideas to improve the production process, they rely on simulation mathematical testing and experimental data processing (Muradilloyevich et al., 2020) to achieve their goals. Similarly, in TVET training, simulators are indispensable tools. It helps to create realistic virtual environments and practice scenarios and allows TVET trainers to experiment with different techniques, tools and materials without damaging costly equipment. Moreover, simulators provide immediate feedback on performance metrics such as speed, accuracy and safety compliance. TVETMARA educators incorporate simulators as part of their course syllabus, utilising simulators as one of the ICT tools in STEM teaching, particularly in practical classes. By doing so, they equip TVETMARA students with the necessary skills and knowledge to succeed in the industry.

When asked about the ICT tools used in STEM teaching, X2, a TVET MARA electrical instructor, highlighted the function of having a simulator in the electrical workshop to run experiments. He commented that :

> For motor control, there is its simulator – a synchronised motor. It means testing the mentioned motor and how fast the speed of the motor is. For example, if we want the motor running at a certain speed, how much volt and ampere should it have? Most of the courses on electric power use simulators.
>
> (X2)

A former CAD engineer, X5, uses Arduino, an open-source software programmable board, for his electrical circuit class. Arduino boards can read inputs such as light on a sensor and produce output such as motor activating. It is used in many industries due to the growth of wireless technologies such as Wi-Fi and cloud services (Singh Kaswan et al., 2020). He reported that:

> When I first want to use Arduino software in the Sensor Characteristics class, I will inform the students of the software's features. It is a sensor that measures humidity and temperature. To run the program using Arduino, the student has to construct its circuit and then connect it to the laptop. Then, only he can compile and run the program, whether there is an output or not.
>
> (X5)

Using a different type of simulator in electrical and electronic class, X8 uses an educational simulator called multisim. It is an industry-standard SPICE simulation and circuit design software for analogue, digital, and power electronics. Using multisim software, X8 assists her students in circuit design and improves prototype performance.

> To teach Electrical Circuit 2, I use PowerPoint for theory class. During lab assessment, I am using multisim online software. I will teach the students on the setting - how to place the capacitor, to get the output and read the results.
>
> (X8)

Supported by X9, a mechanical engineering lecturer and a Head Department, the selection of ICT tools in STEM teaching is based on the learning outcomes of TVETMARA courses. TVETMARA teachers conduct their classes guided by teaching and

learning materials provided by the curriculum division in BKT and the requirements of JPK.

The second aspect generated in the Criteria for ICT selection theme is that TVETMARA teachers will likely select ICT tools based on active teaching strategies. In light of the rapid development of technology in IR 4.0, TVET has transformed the way it delivers its content by focusing on teaching skills (Asnul Dahar Minghat et al., 2020; Mohamad et al., 2019; Zulnaidi et al., 2020). To keep up with these changes, TVETMARA adopts active learning techniques that provide a more engaging and interactive learning experience. This approach aims to promote deeper understanding and high retention of the learning materials in TVETMARA courses.

In TVET, active teaching strategies gained widespread acceptance, particularly in Engineering disciplines (Hartikainen et al., 2019; Mcpherson & Foncha, 2022). These strategies encourage students to actively participate in learning, enhancing their understanding and retention of the material. These methods employed in TVETMARA include problem-based learning, demonstrations, group discussions and hands-on activities. Furthermore, active teaching strategies align with the STEM teaching approach, emphasising a hands-on, experiential learning style (Nurtanto et al., 2020). By incorporating ICT tools such as video-based, PowerPoint and online teaching in active teaching strategies, TVETMARA educators can create a collaborative and supportive learning environment for their students.

One common view shared by interviewees is the use of videos to showcase technical processes. In TVETMARA classes, demonstrations are an active and engaging learning approach that allows students to observe, analyse and replicate tasks in real-time. For example, X1 utilises videos from YouTube to demonstrate tasks such as disassembling

car parts. Based on the video, he instructs his students to create their video on assembling car parts, using techniques shown in the video.

Similarly, in a Material Engineering class, X9 uploads videos to show the processing of raw industrial materials into finished products. Because it is a complex process involving a material's chemical, thermal, and physical properties, watching videos helps students engage in the class. Moreover, TVET students prefer learning through visual aids that provide a simulation of the process(Rahman et al., 2022). He said that:

> I use videos and slides to demonstrate the heat treatment process. The video shows the heat treatment implementation and how it strengthens finished products. It is done on swords and knives by melting and cooling phase. I play videos for my students to watch, making my explanation clearer.
>
> (X9)

X10 shared his positive views on the effectiveness of using videos as a visual aid for demonstration in a hands-on session of a practical class. During a class observation, he demonstrated the movement of a system in his mechanical class. By showing the process, he was able to explain the concept to his students effectively. In his interview, he stated that:

> In a hydraulic and pneumatic class, I use videos. These videos illustrate hydraulic equipment movement in three dimensions. It is in a 3D drawing where we can see movement from the inner and outer sides. So students can observe and discuss from every angle. This is an effective method for my students.
>
> (X10)

On the other hand, X3 noticed a lack of videos available on YouTube that represent the electrical practices in Malaysia. He found most videos from foreign countries such as India and Pakistan. As Malaysia has its standards and regulations, X3 took it upon himself to create his videos to demonstrate the Electrical Act and regulations in the country. By doing so, he hopes to provide his students with a better understanding of the practices conducted in their own country. He said that:

> Most of the videos for the electrical field that I found on YouTube are from foreign countries like India and Pakistan. There needs to be more video from Malaysia. Whereas, in our country, we have our standards and regulations. I take this opportunity to make videos that show the practices conducted in our country.
>
> (X3)

However, there are divided views on using ICT, such as videos in a practical workshop. Some informants found using ICT in practical workshops challenging since face-to-face teaching is more practical. X2 acknowledges that specific tasks can be effectively taught through online videos but emphasises the importance of live demonstrations for complex concepts. He commented in the following interview excerpt:

> For practical classes, there are some tasks that I can use video, which can be done in online teaching. Nevertheless, some tasks need to be demonstrated in live mode. For example, when I am teaching on heat-shrink. I will mention the term to the students and explain the function of heat shrink as a heat insulator between joint cables. The students need to experience the learning. Then, only they understand the concept of heat shrink.
>
> (X2)

X8 also expresses concern about the limitations of videos in achieving desired learning outcomes for wiring electrical circuits. To ensure that her students receive a comprehensive education, she arranges for them to attend practical workshops at the TVETMARA centre.

> Students need to come to the centre for a practical wiring workshop. Hands-on means the class implements practically. Later, during practical training, students interface with real situations. So, they need to experience through their senses and psychomotor.
>
> (X8)

In contrast, TVETMARA educators teaching Engineering drawing in Computer Aid Design (CAD) classes found ICT beneficial to conducting practical classes. X4, for example, uses videos to demonstrate the task of Mechanical Drawing.

> In the practical course, I uploaded and shared several videos. Video-based is needed in the subject I teach. Sometimes, I will share more than one video for each unit with the students.
>
> (X4)

Besides video, interactive PowerPoint slide presentations also help students enhance their understanding of respective fields, whether in a theory class or a practical workshop. Slide presentations containing infographic features become a visual aid that can increase students' engagement. X6 commented that:

> Using PowerPoint to present my teaching content attracts my students' attention. Features such as infographics have an impact on the way I deliver. It smooths the learning process and captures the students' interest compared to solely whiteboard.

> When I start writing on the whiteboard, students easily get bored. I received a positive when I started using ICT PowerPoint with infographics. Students enjoy looking at pictures rather than words only.
>
> (X6)

Several TVETMARA educators discovered the benefits of incorporating videos and PowerPoint slide presentations into their classes. For instance, X3, who teaches the Electricity and Supply Act and Regulations course in online teaching, uses images in PowerPoint slides and videos from the internet to emphasise the importance of adhering to rules and regulations as an enforcement body of the Energy Commission. He attempts to engage students in class discussion by visualising real work situations.

> A theory class such as Act is still doable using a discussion format for online teaching. Even though I cannot show real-life examples, I use images and videos from the internet. I will show my students the consequences of not abiding by an act in one scenario and the different effects in another.
>
> (X3)

X7, an architectural design expert, uses AutoCAD and PowerPoint slide images to teach her Design Building online theory class. She said:

> Usually, I prepare my slide presentation based on units. I will arrange it according to the syllabus. I use as many images as possible to demonstrate to my students until they can interpret pictures. Sometimes, I use Google Maps to zoom in and out of a country. Various software used for designing, such as AutoCAD, Sketch,

> Adobe Photoshop and Illustrator. All mentioned software is included in the syllabus.
>
> (X7)

She also records her videos to allow her students to learn independently. In her video class observation, she demonstrated the drawing of two-dimensional shapes with measurements in AutoCAD software. This enables her students to grasp and recall important details of the drawing process easily.

Using online platforms such as Google Classroom, Teams and Online chat becomes a means to communicate between TVETMARA educators and their students. A project-based learning, such as a final year project, involves a lot of discussion between teacher and students and their peers. The discussion enables students to analyse the problem context and explore possible solutions by sharing experiences and opinions. X3 explained that:

> In a theory class, even doing it in Microsoft Teams, I would have group discussions among the students. Each group receives a problem situation where they must apply the Act and Electricity Regulations. During presentations, there will be interactions through QA sessions with the whole group of students. The class becomes lively with two-way communication.
>
> (X3)

X8 highlights the advantages of online chat and video platforms for facilitating group discussions with her students. She expressed great satisfaction when more students actively participated in the discussions.

> I encourage my students to communicate through WhatsApp groups for any inquiries related to the lessons. However, in cases where I need to do a thorough explanation, I utilise Microsoft Teams. My main goal is to clarify any misconceptions and ensure my students fully comprehend the material being taught.
>
> (X8)

In brief, TVETMARA educators advocate and support the integration of ICT tools in STEM teaching. These tools are selected based on two critical criteria: the curriculum needs of the TVEMARA syllabus and the implementation of active teaching strategies. TVETMARA educators ensure that the students are equipped with the necessary skills and knowledge in the chosen technical fields by selecting tools such as AutoCAD software for engineering drawing classes and simulators that align with the industry requirements.

Additionally, the incorporation of visual aids such as videos and PowerPoint presentations into active teaching strategies helps students to grasp complex concepts effectively. Furthermore, online teaching tools like Google Classroom, Teams and online chat enable students to easily access lessons and interact with their educators.

The class observation data revealed varied use of ICT tools, reflecting the educators' alignment with TVETMARA curriculum goals (Appendix J). The observed participants' use of ICT ranged from basic to advanced. It showed a diverse approach in how the educators approached their teaching strategies, often adapting their methods to accommodate the needs of TVETMARA courses and technical students. This can be seen in the class observation of TVETMARA Educator X1, who utilized Google Meet and YouTube videos to scaffold his class discussions on automotive engineering, integrating

inquiry-based learning. Before he started his lesson, X1 asked the class, 'What do you know about engines? What are the basic operations?' Then, X1 continued explaining the lesson's learning outcomes. When he moved to a new lesson development, X1 asked about previous lessons to make sure his students grasped the lesson. Despite the fundamental nature of XI's use of ICT, it matched the practicality of the Fundamental Engine course and engaged students through interactive questioning.

Conversely, X7, an Electrical TVET instructor, relied on Microsoft Teams and PowerPoint to deliver electrical regulations content in a more teacher-centred manner. However, even within this structured approach, he infused moments of inquiry-based learning, adding complexity. This shift between teacher-centered instruction and inquiry-based exploration demonstrated the diversity of X6's teaching style—moving between straightforward content delivery and deeper student engagement.

Similarly, X4 and X8 exhibited more expertise in their teaching strategies by including more advanced ICT tools like AutoCAD in their lessons. X4's focus on technical drawing through AutoCAD, combined with visual, auditory, and kinaesthetic elements, created a multi-faceted learning experience that balanced complexity with student accessibility. This high level of ICT integration aligned strongly with TVETMARA's goals of promoting technology-based skills in engineering fields.

X5 took ICT integration further by using simulators such as Arduino and Matlab in his IoT class, effectively blending engineering content, STEM teaching, and ICT. His teaching exhibited in-depth as he managed diverse student abilities while ensuring that complex technical tools were accessible and relevant to real-world engineering problems. Similarly, X10 employed simulators to demonstrate pneumatic and hydraulic systems, creating an immersive learning environment of power transmission in industrial

applications that moved from basic fluid power systems to advanced, practical applications.

Overall, the selected ICT tools were suited to TVETMARA's curriculum goals, with observed participants showing both diversity in their adaptability and complexity in managing the complex interplay of ICT, TVETMARA courses, and STEM teaching. While some educators used more traditional, straightforward methods, others leveraged ICT to create dynamic, interdisciplinary learning environments that reflected the STEM-focused objectives of the TVETMARA institution.

In Lesson Plan analysis, the curriculum goals are strongly aligned with the use of ICT, ensuring students achieve key learning outcomes. For example, in LP1, the integration of PowerPoint slides, LCD projectors, and videos directly supports the teaching of critical concepts like first-order circuits and energy storage elements. These multimedia tools ensure students can engage with complex content visually and practically. In the LP2 lesson, the curriculum goal of developing dimensioning skills is achieved through the use of AutoCAD 2021, a crucial tool for students to practice real-world CAD techniques. This alignment ensures that the curriculum’s technical focus is met using industry-standard technology.

In contrast, the LP3 lesson plan focuses on delivering theoretical knowledge of legal regulations using Microsoft Teams and information sheets. These tools align with the curriculum's goal of ensuring that students understand the responsibilities outlined in the Electricity Supply Act. However, while this approach is functional, there is room to enhance the curriculum’s alignment by incorporating more interactive technologies. Overall, the lesson plans show a clear focus on curriculum goals, but they vary in their depth of technology integration.

The teaching strategies in these lesson plans emphasize a blend of theoretical instruction and practical application. In LP1, the use of problem-based learning (PBL) and exercise sheets helps students transition from understanding theoretical circuits to solving real-world problems. This balance of teaching methods ensures that students are engaged both mentally and practically. Similarly, the LP2 lesson combines hands-on learning with theoretical explanations, using AutoCAD to help students apply dimensioning techniques in real-time. The use of the Sharing" method provides personalized guidance, allowing for direct application of learned concepts.

However, in the LP3 lesson plan, the teaching strategies lean more toward lecture-based content delivery, using question-and-answer sessions and interactive discussions to engage students. While these methods effectively support theoretical instruction, the practical component could benefit from additional interactive tools, such as case simulations or legal scenario-based activities, to better engage students in applying regulatory concepts. The strategies across the lesson plans effectively support learning, but they vary in how much emphasis they place on combining theory with practical skills.

The information on this theme helped develop and construct ICT selection in the instrument phase of the study. Table 4.1 presents the codes related to the ICT selection construct in the STEM ICT Teaching Inventory and excerpts from data sources.

Table 4.1: Criteria of ICT Selection Facilitate Development of ICT Selection Construct

Codes	Description	Statements/Terms represent- extracted from interview transcripts	Class observations	Lesson Plan	TPACK Domain
Curriculum goals	ICT selected is aligned with courses/learning outcomes	AutoCAD fundamental for engineering drawing, inventor upgraded drawing from 2d to 3d, troubleshoot, simulator, basic engineering, advanced technology, Arduino, online software	Observed -ICT tools such as AutoCad is part of the syllabus in technical drawing	Documented	TK TCK
Teaching strategies	ICT selected is aligned with teaching method used in theory and practical classes	online class, theory class, practical class, demonstration, hands-on, problem based, project based, learning outcomes, two-way communication, inquiry based, grouping, case study	Observed – using video and PowerPoint for demonstrations	Documented	TK TPK

4.2.2 Theme 2: Organisation Support

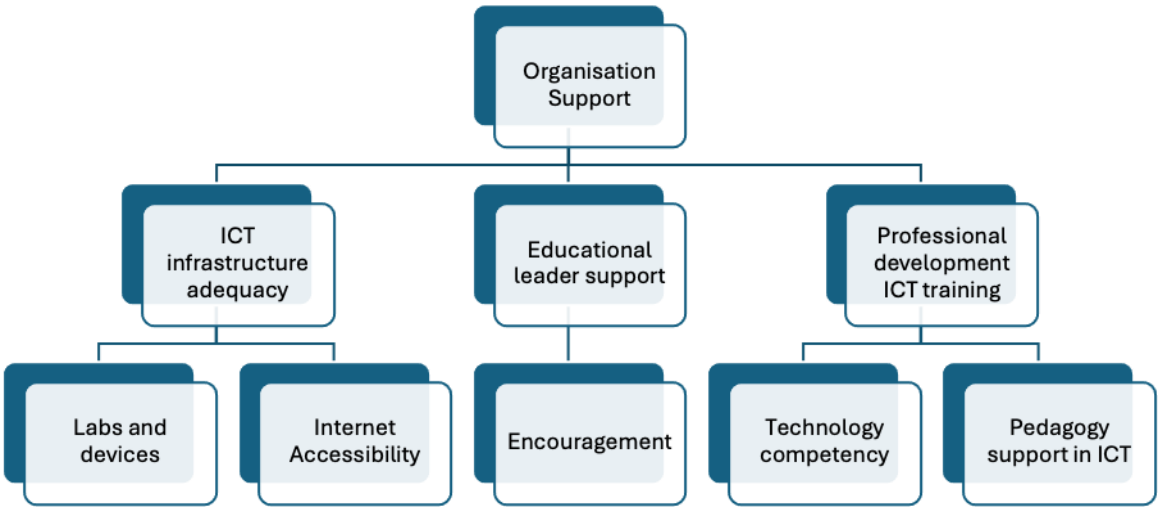


Figure 4.3: Concept Map for Theme 2

The qualitative results for Theme 2, Organisational Support, highlighted three aspects: ICT infrastructure adequacy, educational leader support and professional development ICT training. By addressing these aspects, TVETMARA can help educators overcome the challenges of integrating ICT into STEM teaching. It is the nature of ICT technologies as they are ever-changing and unstable. This makes it difficult for educators to stay updated with new ICT technologies. Therefore, education organisation plays a significant role in providing ongoing support to educators (Ryan & Bagley, 2015). Though the use of ICT in teaching depends on the organisational context, the organisation's culture they must conform to may need to understand how technology can be used effectively in teaching.

The first aspect of Organisational Support was the adequacy of ICT infrastructure to support STEM teaching based on the TVETMARA curriculum. ICT infrastructure is

considered an external challenge that affects technology integration in the classroom (Ertmer & Ottenbreit-Leftwich, 2010; Ryan & Bagley, 2015). The lack of ICT infrastructure can be seen as an obstacle when educators integrate ICT into their teaching (Fu, 2013; Salehi & Salehi, 2012). Consequently, the establishment of a suitable information and communication technology (ICT) framework is of utmost importance in order to enhance the educational experience (Ngeze, 2017).

Recognising the importance of ICT in education, TVETMARA has implemented a Digitalisation Program to support its teaching staff by equipping them with the necessary ICT tools and skills to achieve high-quality education. One of the key initiatives is to increase the number of ICT infrastructures, such as labs and teaching devices. It hopes to accelerate the ICT integration process in STEM teaching by providing more ICT tools. Moreover, TVETMARA is committed to supporting its educators financially and involving them in the decision-making and planning process of the Digitalisation Room. This is an opportunity for the TVETMARA educators to have a say in implementing ICT tools and tailor their use to meet the needs of STEM teaching. This is stated by X2 when he was asked about the support that he received from TVETMARA:

> The organisation's efforts in moving towards digitalising the teaching and learning process can be seen through the digitalisation program. As part of budget allocation, we have requested to discuss and propose the devices we need to support our teaching. In my department, we also have set up our digitalisation room..using the available space and adding new ICT tools.
>
> (X2)

X8 shared some fascinating insights on how the Digitalisation Program has impacted her TVETMARA centre. These changes have been bothx positive and challenging to the educators. Below is the evidence of the changes that occurred:

> Now, our laptops have been upgraded to 500G, and additional RAM has been installed. The impact of the digitalisation program is evident in every corner of the centre…even our meeting room looks different. The library has also been transformed to suit the needs of our organisation in this digital era. Under this program, each department will receive a fully equipped room with 3D teaching tools. I have even heard there will be Virtual teaching tools such as VAR Visual Augmented Reality..but I am not sure if it has been approved yet.
>
> (X8)

Unlike X4, who teaches at another TVETMARA centre, the Digitalisation Program has allowed her full access to the laboratory facilities to conduct her technical drawing lessons. She conducted her classes smoothly with the accessibility of ICT facilities. She commented:

> There are seven software programs available in six labs. Each consists of 20 desktops. Each lab is designed for a different semester with different software upgrades installed. For example, 1st-semester students will use Lab 555 with CAD. In the 2nd semester, a different lab will be installed with different upgrade software. In the 3rd semester, more sophisticated software will be used. However, the basic knowledge of this software will be AutoCAD. Each lab has smart TVs and smartboards, making learning more interactive and engaging.
>
> (X4)

However, having sufficient ICT infrastructure is not enough. TVETMARA must also maintain and update its ICT tools and software. This is necessary to be in line with the technological tools used in the industry. An example of software that needs to be updated is AutoCAD. This is commented by X1 on the licensing of AutoCAD software:

> When there is a need to upgrade the drawing software for the 3rd-semester automotive diploma students, our management should be aware of the problems faced by instructors when licenses expire. Failure to renew licenses can result in classes not running smoothly. Therefore, our organisation should be alert to situations related to software licensing.
>
> (X1)

X6, who has been teaching since 2004, has noticed that the ICT infrastructure has improved a lot. When he started teaching, there were only overhead projectors available. However, from 2007, teachers were provided with laptops, computers and digital projectors. However, teachers had to share the equipment with others at the beginning of their use. There have been more ICT tools since he moved to his current centre in 2010. Also, new ICT materials and equipment are being purchased to set up the Digitalisation lab.

In an evolving digital era of IR 4.0, internet accessibility has become crucial in ICT integration into teaching practices (Shahroom & Hussin, 2018). Therefore, insufficient access to the internet can be an obstacle for educators to embrace technological advancements fully. The limited access to the internet hinders educators' ability to fully leverage the benefits of ICT for effective teaching (Ghavifekr et al., 2016; Salehi & Salehi, 2012). Even though TVETMARA has enhanced internet accessibility in most of its

centres, connectivity is still slow to support the seamless use of ICT to facilitate instruction activities. In Electrical class, X6 required his students to search for information for their assignments online. However, he expressed his concern about the accessibility of the internet, which was not stable in the lab and caused his students to be unable to complete the task on time.

> However, we have a problem regarding the internet server in the lab..sometimes students have to use their internet data (hotspot). When I need my students to search for references on electrical acts and regulations, they have to use their hotspot. In the lab, there is internet, but it is not stable. We proposed a new internet server, yet the purchase was postponed.
>
> (X6)

X1 and X5 also shared the same view on how internet accessibility affected the effectiveness of ICT integration into STEM teaching. X5 expressed his opinion on the lack of support received by students on internet connectivity. He said that:

> I think there is sufficient support from the management (organisation) regarding training or facilities for TVETMARA lecturers. However, there is still a lack of ICT infrastructure for students. The internet access of students is limited and controlled. I assume the management thought the students were unprepared for such a culture.
>
> (X5)

Another valuable piece of information obtained from the interviews was the significant impact that educational leaders at TVETMARA institutions have in promoting and facilitating the integration of ICT in TVETMARA classrooms.

Educational leaders must understand and become well-versed in the role of ICT in the TVETMARA curriculum in the aspect of course learning outcomes and the needs of the industry. Administrators and leaders are expected to provide robust and convincing leadership for the smooth flow of ICT integration (S. Yildirim, 2007). TVETMARA educational leaders display this element. TVETMARA educators gain support from their TVETMARA educational leaders in various forms like providing resources, motivation and training. The leaders encourage and recognise the efforts of educators in incorporating ICT in their STEM teaching. For example, X3 was very impressed with the ideas given by his educational leader, who could foresee the need for video-based learning in practical classes. Due to this, they overcame the challenges of conducting practical classes, especially during Covid-19.

> Initially, ideas on using videos for demonstration purposes were proposed by the former director…at first, I was reluctant and disagreed. When Covid-19 occurred, we did not want our students to fall behind in classes. The idea.. was again proposed by the deputy director at TVETMARA headquarters. They explained how videos could assist students in preparing before returning to the TVETMARA centre to complete their practical classes. Hence, video-based learning comes in handy during COVID-19.
>
> (X3)

In order to promote more potential digital teaching materials developed by TVETMARA educators, TVETMARA educational leaders have taken the initiative to include them in the measurement of key performance indicators (KPI).

Since technologies are never stable and constantly evolving, TVETMARA educators are overwhelmed with keeping up with the latest technologies and techniques. Therefore, TVETMARA leaders must allocate adequate resources and time to the learning process. In the interview, X7 expressed her gratitude about how considerate her Head of Department was in allocating classes so educators could adapt to online teaching during COVID-19. She commented on how her head of department arranged their timetable, so they had time to explore the use of ICT in their teaching.

> Since my department needs more instructors and needs to prepare teaching materials for each course, our Head of Programme decided to keep our timetable and allocate classes taught. That is why, during covid 19, we have been teaching the same courses for two semesters. This allows us to adapt to online teaching that we have yet to get used to.
>
> (X7)

Though there is a great emphasis on ICT in education, educators still need to work on using ICT to enhance their teaching and learning process(Fu, 2013; Salehi & Salehi, 2012). This is because they are not adequately trained in using ICT tools for educational purposes. Therefore, education organisations invest in providing professional development training for educators to incorporate ICT effectively.

In supporting TVETMARA educators to instil the practice of integrating ICT in teaching, TVETMARA educators need professional development training. It is also part of the initiative of TVETMARA under the Digitalisation Program to provide ICT training to equip TVETMARA educators with the necessary skills and knowledge to integrate ICT tools in STEM teaching. Based on the interviews with TVETMARA educators,

TVETMARA still lacks practical ICT training in pedagogical support. For example, X6, who attended various technologies competency training used in his field but not the one that supports effective teaching. He said :

> I have upgraded a lot of my technological skills used in the electrical field. When I first learned about PW4 wiring, I took computer class L1. When my centre involves solar energy training, I update my competency in solar. However, for ICT tools like Microsoft Teams used for teaching during COVID-19, we received an explanation on how to use them initially. Then, I explore how to use the features, for example, the breakroom. If I am not sure, I will look it up on YouTube.
>
> (X6)

X7 also shared her experiences attending AutoCAD software training to focus more on using the software rather than how to teach using AutoCAD.

> The organisation helps TVETMARA educators enhance their technical drawing skills using software by sending them to train organised by outsourcing. To ensure the quality of teaching, all instructors who teach AutoCAD must participate in and attend the competency test. However, the training focuses more on how to use the software. Some technology training was conducted after they had started teaching for a few semesters. I do my exploration. Attending the training is an added value. Nevertheless, the organisation is still giving training with new technology tools.
>
> (X7)

X3 received several ICT trainings during his industrial experience. Instead, he opted for online training such as Microsoft MIE. Interestingly, most TVETMARA

educators interviewed showed a strong inclination towards independently discovering and experimenting with ICT tools. They seem to value the freedom and adapting with self-learning to gain proficiency in ICT tools. Educators within the Technical and Vocational Education and Training (TVET) system display a demonstrable commitment to acquiring knowledge and skills in emerging technologies. This suggests they are highly driven and desire to improve their skills and knowledge.

The information on this theme helped with the development of construct Organisation Support in the instrument phase of the study. Table 4.2.2 presents the codes related to the Organisation Support construct in the STEM ICT Teaching Inventory and excerpts from data sources.

Table 4.2: Theme Organisation Support Facilitiate Development of Organisation Support Construct

Codes	Description	Statements/Terms represent- extracted from interview transcripts	Class observations	Lesson Plan	TPACK Domain
Digitalisation Program	Initiative of TVETMARA organisation to provide support to TVETMARA educators	Allocating budgets for ICT devices and labs, buying teaching materials and devices based on fields specialisation needs	Not applicable	Not applicable	TK
Educational leader support	TVETMARA leaders involvement in supporting teaching staff to integrate ICT	Giving ideas and encouragement to TVETMARA educators for video based learning, allocate time for learning	Not applicable	Not applicable	TPK XK
Professional development ICT trainings	ICT training based on competency and pedagogical support	Competency training includes AutoCAD software for technical drawing, Microsoft training, exploring ICT tools	Not applicable	Not applicable	TK TPK XK

4.2.3 Theme 3: Peer Collaboration

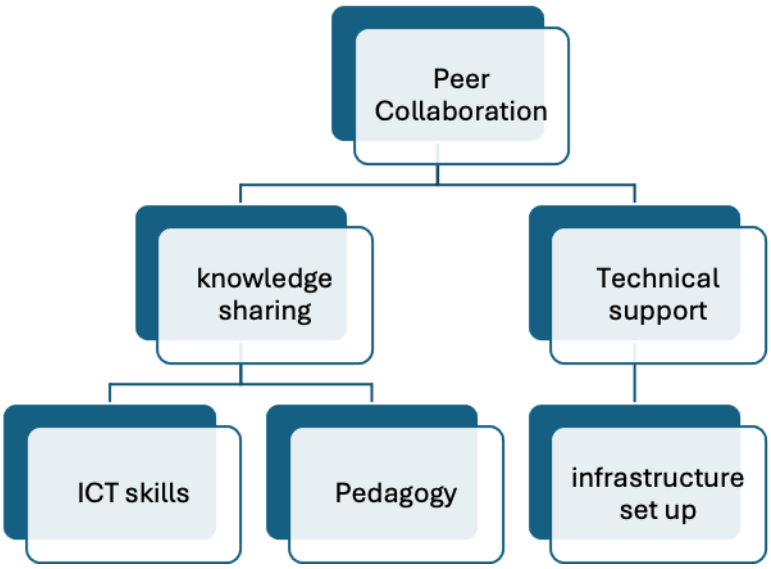


Figure 4.4: Concept Map for Theme 3

Integrating ICT in STEM teaching can potentially enhance the teaching and learning experience (Chan & Fitri Suraya, 2019; Lukychova et al., 2022b). However, for educators, this task can be quite challenging (Fu, 2013; Habibi et al., 2020; S. Yildirim, 2007). Some challenges educators face are ICT and internet access and insufficient technical and professional development training (Ertmer & Ottenbreit-Leftwich, 2010; Ghavifekr et al., 2016; Salehi & Salehi, 2012). Therefore, TVETMARA educators need to create an appropriate learning environment to maximize the effectiveness of ICT technology. Peer collaboration, as identified through qualitative findings, emerges as a valuable theme that facilitates the integration of ICT in STEM teaching by TVETMARA educators. Within TVETMARA, two significant collaboration activities are knowledge sharing and technical support by non-teaching staff. These collaborative initiatives improve TVETMARA educators' ICT skills and contribute to their pedagogical development through exchanging ideas and experiences.

During the interviews, the majority of the participants stated that they learned a lot from their colleagues, who are considered experts in the organization. Interestingly, one TVETMARA educator described his colleagues as catalysts, playing a crucial role in his attempt to incorporate ICT into his teaching effectively. He mentioned that:

> I did not explore on my own; I had the assistance of my friends. They acted as catalysts, provoking my curiosity to learn more about the technology.
>
> (X3)

X3 was added as a member of a learning group. They discussed and shared the latest discoveries and advancements in ICT tools that can be effectively used to improve their teaching strategies. For example, he shared how he acquired knowledge about Class Point, an interactive teaching feature in PowerPoint. Meetings and meaningful discussions with some colleagues in the TVETMARA centre expand their skills and knowledge of using Class Point. X3's engagement in the learning group made his teaching practice innovative.

Moreover, the implementation of Class Point resulted in remarkable outcomes. His students responded positively to the dynamic and engaging teaching sessions facilitated by Class Point. Their enthusiastic participation and feedback motivated X3 to incorporate more ICT tools that can create a lively class.

Furthermore, collaborative activities like knowledge sharing allow TVETMARA instructors to share effective teaching practices and new ideas. They can incorporate effective teaching methods by exchanging ideas and experiences. As a result, they can overcome obstacles. For example, during the challenging period of the pandemic, one TVETMARA participant (X8) shared her experience of receiving assistance from her

colleagues. As TVETMARA institutions transitioned to online teaching, X8 navigated new digital tools, particularly Google Classroom and Microsoft Teams, to facilitate remote learning. Recognizing the expertise within her collaborative network, she sought assistance from her colleagues. Another educator, X4, also had the same experience as X8. She said that:

> During the pandemic, I did not attend any formal training on using Google Classroom last semester. I had to explore independently and turned to my colleagues for help. I received great assistance from them, as I lack knowledge of ICT in teaching.
>
> (X4)

The collaborative support for knowledge sharing assisted X4 in adjusting to the new teaching environment that the COVID-19 pandemic presented. Realizing the need to ensure continuity in student learning, TVETMARA educators support one another to overcome the challenges and barriers to integrating ICT tools in pedagogical developments.

Active involvement in knowledge sharing can improve the quality of the TVET environment (Hanimastura et al., 2016). TVETMARA educators engage in sharing teaching materials among their peers. Group discussions, document sharing and the implementation of best practices contribute to the pedagogical development of TVETMARA educators' teaching practices. For instance, documents, such as lesson plans and teaching modules, are stored in an online system called BKT Cloud Storage (BCoS). TVETMARA educators from 15 different locations can assess documents on teaching and learning using ICT. Lesson plans and reflections by educators on effective practices of ICT

integration that work well in their classrooms support growth and innovation in teaching practices.

The exchange of class demonstration videos is a popular example of sharing teaching materials. When asked about collaborative activities in their centres, most TVETMARA educators responded by uploading teaching videos to YouTube channels that their peers from other locations might use. This enables TVETMARA educators to reach a larger audience and benefit from shared information and skills, promoting continuous professional growth within TVETMARA sectors. On the other hand, the lack of constructive discussions of shared teaching materials among TVETMARA educators reduces the potential for creating a positive environment in collaborative activities.

Sharing knowledge in collaboration activities also occurs in formal settings, such as conducting short courses across disciplines. Cross-disciplinary collaboration brings together unique expertise, perspectives and approaches to problem-solving from various disciplines and engineering backgrounds. X7, who teaches AutoCAD for technical drawing, learns AutoCAD from the perspectives of numerous engineering fields. She illustrated this interview excerpt:

> Initially, the AutoCAD course was taught by an instructor from the architectural department. However, as part of the emphasis on the Live Long Learning Program (PSH), I now conduct courses on teaching AutoCAD to instructors from other engineering departments, such as automotive and mechanical engineering.
>
> (X7)

Thus, cross-disciplinary collaboration expands educators' knowledge and enhances their teaching expertise. Educators can tackle complex challenges more effectively by

integrating insights from different disciplines. They can approach problems from multiple angles, draw diverse resources and apply innovative solutions. It allows them to become adaptable in class educators as problem solvers. Collaboration across disciplines facilitates communication and understanding between different fields, bridging gaps between engineering areas that lead to new collaborations and interdisciplinary initiatives. Exchanging ideas and best practices leads to improved teaching methodologies among TVETMARA educators.

Nevertheless, TVETMARA educators prefer self-learning when exploring ICT tools, as it provides them with flexibility in terms of time and learning pace. X8, one such educator, shared her perspective on this matter. According to X8, she engaged in self-exploration, except when encountering areas where she lacked knowledge. This is illustrated in the interview excerpt:

> Yes, I do self-explore, except if I do not know…I will ask my colleagues and friends for assistance. However, they are also occupied with other tasks. So, most of the time, I will do self-study. For example, when I learned how to use Adobe Photoshop, I explored independently without any guidance from an expert. I am currently interested in videomaking and learning the art of video editing.
>
> (X8)

Hence, regarding educators' collaboration, comments from X8 highlight the importance of educators' collaboration in supporting educators' learning journeys. When TVETMARA educators encounter challenges, collaborating with peers allows them to recognize the value of seeking support from others. It can take various forms, such as in formal or informal discussions of professional development sessions.

The second collaboration activity within the TVETMARA community is receiving technical support from technical teams and students' apprentices. Technical support is essential for educators as it empowers them to overcome technical barriers, equips them with necessary skills and facilitates effective integration of ICT tools in STEM teaching. Technical support ensures that the necessary hardware, software and network infrastructure are appropriately set up and maintained. This includes installing and configuring devices such as computer projectors and ensuring a reliable internet connection. Without proper infrastructure, educators may face difficulties using ICT tools effectively in their teaching. This view is shared by X4, who expressed her gratitude for her centre's technical support.

> I am fortunate to have a skilled technician in my centre. I will make sure to include the technician in the WhatsApp group of my students. In case students face difficulties installing software or encounter technical issues, he provides valuable assistance. I am not very proficient in technical matters. However, when students experience laptop performance issues or software problems like AutoCAD, I contact the technician for immediate help. While I may have limited knowledge in this area, branded laptops are not always necessary. I also know the minimum processor specifications commonly recommended for smooth software operation.
>
> (X4)

X4 illustrates how TVETMARA educators rely on the technical team's expertise in the TVETMARA centre, especially when it comes to laptop issues and software-related problems like AutoCAD. It shows that X4 understands technical requirements but needs to improve handling hardware and software infrastructure set-up.

Besides the technical team, TVETMARA educators also receive technical support from students' apprentices to assist in troubleshooting and problem-solving. They help to resolve any technical issues TVETMARA educators may encounter while using ICT tools. This includes software glitches, connectivity problems or hardware malfunctions. X4 receives assistance from her students' apprentice to help with hardware malfunctions. She added that within the first few months of her class, she will identify 2 to 3 students who showed competency in handling technical problems. This group will later assist other students in installing the required software on their laptops and devices. Prompt troubleshooting helps minimize classroom disruption and allows educators to focus on teaching rather than technical challenges.

In the observed classroom settings, peer collaboration between educators, colleagues, and students was notably influenced by both the integration of ICT tools and adherence to TVETMARA's curriculum goals. Educators like X1 exhibited a collaborative teaching approach by engaging students in inquiry-based learning, which allowed for peer interaction and discussions. X1's use of ICT tools such as Google Meet and YouTube videos to facilitate this collaboration reflected his effort to align with the curriculum while fostering a learning environment that supported teamwork and problem-solving. This indicates a practical use of ICT not only to deliver content but also to encourage collaborative learning among students.

Similarly, X7 demonstrated a collaborative relationship with students through the use of Microsoft Teams and PowerPoint presentations. While his class initially followed a teacher-centered approach, the inclusion of inquiry-based learning moments encouraged students to participate actively in the discussion. This reflects an educator who balances structured content delivery with moments of peer collaboration, utilizing ICT to create

spaces for interaction between students and the educator, which aligns with TVETMARA's goals of developing critical thinking and problem-solving skills.

In contrast, X4 displayed a more integrated form of collaboration, not only with her students but also in a broader educational context. Her use of AutoCAD software for technical drawing, combined with the incorporation of visual, audio, and kinesthetic elements in her teaching, showcased her understanding of various student learning styles. Moreover, X4's encouragement for students to assist each other in using AutoCAD software highlights an environment of peer-to-peer collaboration. This approach ensured that students were not passive recipients of knowledge but active participants, helping one another, which aligns well with the collaborative spirit encouraged by TVETMARA.

Additionally, X9 and X3 also fostered peer collaboration in their classrooms. X9 used a structured approach by progressing from easy to complex content and integrating workplace examples, enabling students to collaborate through problem-solving discussions. X3, teaching Project Management, utilized ICT tools like Microsoft Project to encourage group discussions, emphasizing teamwork and peer collaboration, a core element of his lesson structure.

Finally, X5 exemplified collaboration in the use of advanced simulators like Arduino and Matlab in his IoT class. His focus on ensuring students' understanding of diverse ICT needs fostered a collaborative environment where students worked together to grasp complex technical concepts. By addressing students' varying ICT capabilities, X5 not only facilitated peer collaboration but also worked closely with his colleagues to ensure that his teaching aligned with broader STEM curriculum goals, as outlined by TVETMARA.

In conclusion, the peer collaboration observed in these classes demonstrates a significant connection between educators' use of ICT and their ability to foster a collaborative learning environment. By integrating ICT tools effectively, educators like X1, X7, X4, X9 X3 and X5 were able to facilitate both student collaboration and interaction with colleagues, thus aligning their teaching with TVETMARA's curriculum goals. This collaborative effort, supported by ICT, underscores the importance of teamwork and peer learning in achieving educational outcomes in STEM disciplines.

The information on this theme helped develop the construct of Organisation Support in the instrument phase of the study. Table 4.2.3 presents the codes related to the Organisation Support construct in the STEM ICT Teaching Inventory and excerpts from data sources.

Table 4.3: Theme Peer Collaboration Facilitates Development of Peer Collaboration Construct

Codes	Description	Statements/Terms represent- extracted from interview transcripts	Class observations	Lesson Plan	TPACK Domain
Discussing with colleagues within centre or other centres	Initiative of TVETMARA educators to develop digital materials	developing videos for demonstration needs, using YouTube channel to upload teaching materials, sharing sessions for upgrading ICT skills	Observed (Collaboration of a topic in lecture conducted by 2 lecturers)	Not documented	TPK TK TCK
Collaborating with students	Initiative of TVETMARA educators to troubleshoot technical problems with the assistance of students	students assisting their peers with technical problems (installing software used in class)	Observed	Not documented	TPK XK
Collaborating with technical group to assist in troubleshoot students' devices	Initiative of TVETMARA educators to troubleshoot technical problems with the assistance of technical staff (non teaching)	troubleshooting – technician assistance to help students with technical problems, preparing software used for online class	Not observed	Not documented	TK TPK XK

4.2.4 Theme 4: Pedagogical Practices

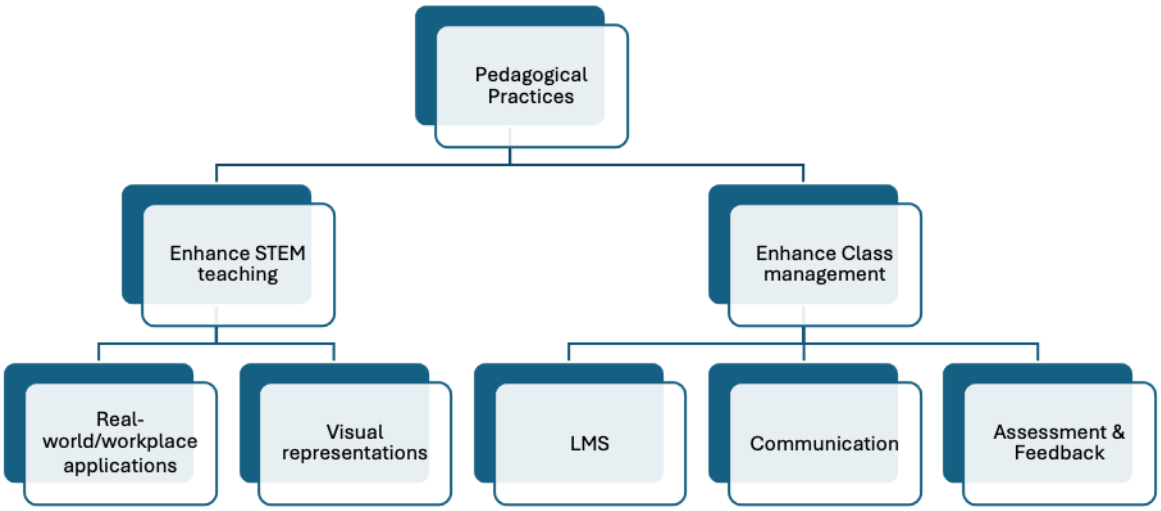


Figure 4.5: Concept Map for Theme 4

STEM teaching has become an essential pedagogical practice in TVET (Asunda, 2014; Dixon & Hutton, 2016; Reeve, 2016). It involves applying theoretical knowledge in practical, real-world situations, emphasizing project-based learning and hands-on projects that reflect workplace challenges (Asunda, 2014; Dixon & Hutton, 2016; Reeve, 2016).. Under the theme of Pedagogical Practices, integrating ICT tools into STEM teaching further enhances its effectiveness and supports the class management skills of TVETMARA educators.

In TVETMARA technical colleges and institutions, ICT tools are now integral to STEM teaching (Chan & Fitri Suraya, 2019; Deák et al., 2021; Mumcu et al., 2022a). These tools provide dynamic and interactive lessons that engage students in exploration activities and promote a deeper understanding of workplace scenarios. Participants in TVETMARA highlight four key elements in STEM teaching: representing workplace applications, visual representations, collaboration and communication, and interactive

learning. TVETMARA participants commonly use CAD software to visualize workplace situations, providing a digital representation of physical spaces, objects, and processes (García et al., 2007; Ibrahim & Pour Rahimian, 2010).

For example, X4, a TVETMARA educator specializing in mechanical drawing and design, teaches a CAD course using AutoCAD software. She emphasized the importance of accuracy in dimensioning and taught her students how to detect potential design flaws in their workshop exercises. She said that:

> I am currently teaching a course on CAD, specifically geometrical construction. When assigning drawing tasks, I emphasize the importance of dimensioning. In their workshop exercises, my students are expected to apply their knowledge of 'fit limit and tolerance.' The designers must examine how components fit together and detect potential design flaws, such as those in manufacturing.
>
> (X4)

Another educator, X6, teaches AutoCAD software in an electrical technical class, highlighting its documentation and reporting features. He found that modifications in drawing designs could be immediately updated with AutoCAD software, ensuring consistency and correctness. X6 demonstrated to his students how ICT tools, such as features in AutoCAD software, allow the real-life work of electrical engineers to facilitate managing design projects through proper documentation and reduce the effort required to implement modifications. He stated that:

> One of the best aspects of using AutoCAD is the ability to save our work in softcopy. This allows for future drawing editing and facilitates record-keeping. It was difficult to compile our work in the past when designs were done manually

with pencil and paper. We had to undergo complicated administrative approval processes if we needed additional design materials.

(X6)

ICT simulation tools, such as CAD software, enhance the design process and showcase real-world applications by highlighting scientific principles (Ibrahim & Pour Rahimian, 2010; Phanden et al., 2020; Ye et al., 2004). These tools help students understand the practical relevance of their learning and encourage them to apply their knowledge to workplace problems. X7, for instance, employs role play in her Basic Architecture Design class to illustrate the working dynamics between a draft person and a customer. She uses interactive sessions, role-play projects, and multimedia platforms to assess her students' progress, evaluate their understanding of design concepts, and enhance their communication skills. Below is her interview excerpt:

In my Basic Architecture Design class, I have implemented a grading system that involves interactive sessions with my students. I assign role-play projects that simulate real-life scenarios to evaluate their progress on each design task. As part of the final assessment, the students are required to deliver a presentation. However, before the presentation, we conduct a grade session where a role-play discussion occurs between the 'owner' and the 'designer'.

(X7)

By conducting online grade sessions in her class observation, X7 provided valuable feedback to her students, guiding them in improving their designs and creating a collaborative environment that mirrors real-world architectural practices. Through multimedia platforms, ICT tools also facilitate interactive learning in the classroom. This

virtual interaction enables X7 to evaluate students' understanding of the design concepts, ability to address client requirements, and communication skills in a realistic setting. Integrating role plays and online platforms in X7's class enhances the learning experience and prepares TVETMARA students for future professional architectural interactions.

Integrating ICT tools into STEM teaching practices offers interactive simulations that enable students to visualize engineering concepts (Yang & Baldwin, 2020a; B. Yildirim et al., 2020). These simulations incorporate interactive graphics, animations, and virtual experiments, fostering a deeper understanding of engineering principles. For example, X8, an educator in electronics, utilizes Multisim software for circuit simulation and analysis. This software allows her students to simulate and predict the behaviour of electronic circuits using mathematical models and algorithms. She shared her experience teaching her students in theory and practical classes:

> In my Electric Circuit 2 class, I employ a combination of teaching methods to ensure a well-rounded learning experience for my students. I utilize PowerPoint presentations during theoretical sessions to deliver the necessary concepts and theories. However, when it comes to practical lab assessments, I incorporate Multisim software. This powerful tool allows me to demonstrate to my students how to set up circuits, place capacitors, analyze outputs, interpret results, and utilize other features. While providing initial guidance, I encourage interested students to explore the software independently. All students must have access to and be able to use the same software, ensuring a consistent learning experience.
>
> (X8)

X8's example highlights how visual representations through tools like PowerPoint and Multisim software enhance STEM teaching in electric circuit classes. Visual aids help students grasp abstract electrical circuit concepts. At the same time, the practical use of Multisim simulation software provides a visual representation of circuits for manipulating parameters and observing corresponding outputs.

The integration of ICT in STEM teaching also supports pedagogical practices in various aspects, including class management skills such as learning management systems (LMS), communication and collaboration, and digital assessment and feedback (Birzina & Pigozne, 2020; Yang & Baldwin, 2020b; Zubković et al., 2022). Participants in TVETMARA acknowledged the convenience of ICT tools like Microsoft Teams and Google Classroom as LMS platforms. These tools assist educators in effectively organizing teaching materials. For example, X5 found Microsoft Teams a convenient platform for storing and sharing teaching notes with students. X5 stated:

> I arranged the slides based on the course syllabi. Then, all the course materials are 'parked' on the Teams platform. Later, my students can access and view them, and even during class, I can share them."
>
> (X5)

X5's approach demonstrates a systematic organization of teaching materials using ICT tools. He ensures that the presentation aligns with the curriculum by cross-referencing the syllabi with the slides. He uses the term "park" to refer to uploading relevant teaching resources for easy accessibility by students.

Most participants also expressed positive views on ICT tools, such as Microsoft 365 apps, for efficient record-keeping, particularly in online classes and discussions. X6

found Microsoft Teams a convenient solution for recording student attendance during online teaching, especially considering some students' limited internet access. Using Microsoft Teams, X6 could easily monitor attendance and ensure active student participation. Additionally, X8 highlighted her experience integrating ICT tools to enhance class management skills during online teaching. She emphasized the importance of student engagement by taking attendance at different learning hours, employing tools like Google Maps to track student locations and manage class engagement effectively. These positive experiences shared by X6 and X8 demonstrate the potential of ICT tools to transform traditional teaching practices and their ability to adapt to embrace ICT tools.

While TVETMARA emphasizes using Microsoft 365 as a productivity and collaboration tool among its staff, participants can choose alternative tools that best suit their teaching style and student needs. For instance, X2 utilizes Google Classroom as the preferred LMS due to its accessibility for students. During the COVID-19 pandemic, X2 conducted online classes using Google Classroom and uploaded all class notes. X2 also utilized WhatsApp to ensure students facing difficulties could access learning materials. This flexibility in tool selection acknowledges and supports the diverse technology usage among TVETMARA educators, leading to effective teaching and learning outcomes.

Educators should utilize various ICT tools to accommodate students' diverse learning styles that cater to individual needs (Karatza, 2019; Sun et al., 2008). X3 serves as an exemplary TVETMARA educator who proactively leverages ICT tools in teaching. X3 effectively utilizes Microsoft apps like Teams and OneNote, gradually introducing these tools to gauge students' acceptance and ensure a smooth transition. By incorporating short quizzes and assignments posted in Teams, X3 seamlessly integrates ICT in the learning process, enhances class management, and equips TVETMARA students with crucial

digital and collaboration skills essential for success in the fourth industrial revolution. As a result, this approach yields positive outcomes for both teaching and learning.

ICT tools are vital in facilitating effective communication and providing timely feedback to students, enhancing the overall learning experience in STEM teaching (Birzina & Pigozne, 2020; Yang & Baldwin, 2020). These tools enable educators to easily share resources, assignments, and important information with students. TVETMARA participants unanimously agreed to use various ICT tools that offer different modes of communication. Video conferencing and instant messaging were commonly utilized, offering distinct benefits for communicating with students outside the classroom. X6 exemplified how he employed ICT tools to communicate with his students, stating:

> Before conducting online classes such as the Electrical Act and Regulations course, I use calendar apps in Teams and WhatsApp to remind my students. Sharing information ahead of time allows students to prepare for discussions. This can ensure a smooth flow of my class discussions and improve my students' engagement
>
> (X6)

X6's use of calendar apps in Microsoft Teams and WhatsApp demonstrates the effective use of ICT tools to enhance communication with students. Through ICT tools, X6 ensures students receive timely reminders about upcoming classes and discussions. Therefore, it creates opportunities for students to prepare adequately and gather relevant materials for Acts and Regulations in the Electrical field. Consequently, students become more actively engaged in the learning process.

Similarly, another TVETMARA participant, X9, shared how he engaged his students in a calculation lesson using instant messaging through WhatsApp. He asked students to share their calculation steps, which served as a form of assessment. This allowed X9 to assess students' understanding of the topic and identify areas that required further clarification or improvement. Students shared pictures of their calculation steps on WhatsApp, which X9 evaluated and provided additional explanations. Through WhatsApp, X9 engaged in text-based conversations, shared resources, and offered clarifications. Additionally, X9 utilized video conferencing to enable real-time interaction, providing immediate feedback and addressing student questions or concerns. Video conferencing facilitated dynamic and interactive communication, fostering better understanding and clarity.

Furthermore, ICT tools provide educators with diverse mechanisms to provide feedback during the learning process, helping students identify areas for improvement (Monther Al Damen, 2021; Wong & Yang, 2017). Feedback can be conveyed through written comments, audio recordings, or video explanations. For example, X7, when assessing drawing submissions, not only provided written comments but also utilized audio comments. X7 explained:

> When students submit their drawing assignments in Microsoft Teams, I provide comments. Besides scribbling on the drawing, I also use audio comments to inform them of accepted and flawed parts. This allows them to identify the flaws in their drawings. Sometimes, I use video conferencing to give feedback to the students.
>
> (X7)

Likewise, X8 also used both instant messaging platforms and video conferencing to encourage students to ask questions. Initially, in her class, queries were addressed through WhatsApp. However, X8 recognized the limitations of textual explanations and found them to need improvement. She turned to video conferencing (Microsoft Teams) for more detailed and comprehensive feedback. This approach allowed her to provide more detailed and comprehensive explanations to address student queries effectively.

Participant X8 demonstrates how ICT tools such as instant messaging foster a supportive learning environment where students feel comfortable seeking clarification and assistance. Using WhatsApp, X8 students have a convenient and accessible way to communicate their queries. Nevertheless, video conferencing enables X8 to visually demonstrate concepts, use visual aids and engage in dynamic discussions. Hence, it offers a richer and more nuanced explanation, ensuring that students grasp the content thoroughly and receive the necessary support in understanding complex topics.

ICT tools facilitate digital assessments (Majid, 2020; Redecker & Johannessen, 2013). They offer various features and functionalities that make the assessment process more efficient, accurate and accessible. Educators have the ability to analyze the advancement of their students and provide prompt feedback by means of online quizzes, interactive examinations, and formative assessment instruments.

Digital assessment platforms can automatically grade objective questions, saving time for teachers. Additionally, educators can use multimedia tools to provide audio or video feedback, enhancing the feedback process and promoting personalized instruction.

Most of the TVETMARA educators who participated in the interview agreed that integrating ICT tools, mainly through Learning Management Systems (LMS) like

Microsoft Teams and Google Classroom, greatly assists in administering assessments. This integration offers a streamlined approach, allowing teachers to conveniently access assessment results, synchronize data and manage assessments from a centralized platform.

One educator, X5, expressed fewer concerns when he conducted assessments in online mode. He asserted that:

> I prefer using Microsoft Teams, which allows me to set specific start and submission times. Previously, when my students submitted their assignments in hardcopy format, it was challenging for me to track if the submissions were on time or not. When I conducted assessments digitally, I could easily identify late submissions and those students who were responsible.
>
> (X5)

With the transition to digital assessments, X5 experiences a significant improvement in managing submissions and identifying any late submissions. X5 can easily access the submission records by utilizing Microsoft Teams for assessments and determine when his students submitted their assessments. The digital assessment process in Teams facilitates the identification of late submissions and provides a more efficient and transparent approach to managing assessments.

X4, another TVETMARA educator, also recognizes the advantages of incorporating ICT tools into the assessment process. She effectively utilizes Teams and Google Classroom to enhance the assessment experience by uploading assessment materials on these platforms. For theory tests, X4 specifically employs a platform called Quizizz. She mentioned that by using online tools to conduct assessments, she could directly obtain her students' marks or scores. Hence, it eliminates the need for X4 for

manual grading or data entry. However, regarding practical tests, X4 implements a specific requirement for students. During the CAD practical test, X4 insists that students must utilize their camera settings. She asserted that:

> When I conduct CAD practical tests, I require my students to keep their cameras on and active throughout the entire three-hour exam.
>
> (X4)

This criterion serves the purpose of enabling X4 to effectively monitor and evaluate the practical tasks executed by students, hence upholding the integrity and authenticity of the assessment.

X3 highlights the increased prevalence of digital assessments due to the COVID-19 pandemic. Digital assessment methods have become more common and necessary with the shift to remote learning. X3 utilized various platforms for online assessments based on the nature of the assessment. For short quizzes, he opted for online forms. These forms provide a convenient and structured way to administer quizzes digitally, allowing his students to submit their responses online. For assignments requiring work submission, X3 instructed his students to take pictures of their completed assignments and convert them into PDF format. This approach allows a standardized format to be quickly submitted and reviewed electronically. However, for his students who were comfortable with more advanced ICT tools, X3 incorporated using Microsoft OneNote for assessments. With features like collaborative editing, real-time feedback and multimedia integration, OneNote provides a digital notebook environment where students can create and organize their assignments (Bamforth et al., 2019; Dieck-Assad, 2018). Thus, these approaches cater to the unique

needs and circumstances of remote learning while facilitating effective assessment practices.

Considering his students' varying abilities to use ICT tools, X8 tailors his assessment approach accordingly. He acknowledges that his students have different levels of proficiency when it comes to using ICT tools. To ensure fair assessment and accommodate the diverse technological resources available to his students, X8 provides alternative assessment methods. He said:

> My exams often require my students to give lengthy answers that involve references to electrical laws and acts. So, typing on laptops may be more convenient for some students than mobile phones. However, only some of my students can access laptops and face difficulties typing lengthy answers on smaller devices.
>
> (X8)

To address this issue, X8 allowed his students to write their answers on paper, a familiar and accessible medium for all students. Instead of directly typing their answers, X8 instructed students to take pictures of their handwritten responses and upload them in online forms. In the context of class management skills, X8 demonstrates adaptability and flexibility in his assessment approach. He ensures that all students can participate in the assessment process regardless of their access to specific devices and comfort level with ICT tools.

Another TVETMARA educator, X9, is aware of the importance of safeguarding the confidentiality of assessment materials using ICT tools. Typically, X9 relied on forms within Microsoft Teams, providing a secure assessment environment. However, a

challenge arose when some of her students needed to use their institution's email address, the standard method of accessing exam questions through Microsoft Teams. This situation posed a potential risk to the security of the assessment materials.

To address this challenge, X9 adopted an alternative approach to sharing exam questions securely. She resorted to using instant messaging applications like WhatsApp to distribute exam questions to students who did not have access to their institution's email. To ensure an additional layer of security, X9 protected the exam questions files with passwords. Using password-protected PDF files, X9 allowed authorized students to access exam questions. X9 showcases a proactive approach to ensuring the security and integrity of exam questions. It promotes fairness, integrity and smoothness of assessment processes.

In other words, using ICT in pedagogical practices enhances STEM teaching by showcasing real-world workplace situations. It also demonstrates abstract concepts and complex processes through visual representation. Hence, it helps students grasp their technical field's practical aspects more effectively.

In summary, the integration of ICT tools in pedagogical practices enhances STEM teaching by providing dynamic and interactive lessons that engage TVETMARA students in exploration activities and a deeper understanding of workplace scenarios. The use of CAD software by participants enables visualization of workplace situations, allowing their students to develop accuracy and consistency in their designs. Moreover, ICT simulation tools, such as CAD software and Multisim, highlight scientific principles and encourage students to apply their knowledge to real workplace problems. These tools provide interactive graphics, animations, and virtual experiments that deepen understanding of engineering concepts.

ICT tools also support class management skills, including attendance and record keeping, learning management systems, communication and collaboration, and digital assessment and feedback. Platforms like Microsoft Teams and Google Classroom facilitate the effective organization of teaching materials and convenient record-keeping, particularly in online classes. ICT tools enable efficient communication through video conferencing and instant messaging, as well as timely feedback through written comments, audio recordings, or video explanations. Digital assessment tools and learning management systems streamline the assessment process, offering features for online quizzes, interactive assessments, and multimedia feedback.

To address students' diverse learning styles, TVETMARA participants should employ various ICT tools that cater to individual needs. By enabling multiple communication channels, individualized responses to instruction, and adaptable evaluation strategies, ICT technologies contribute to a more equitable and productive educational environment.

Ultimately, using ICT in pedagogical practices enhances STEM teaching by bridging the gap between theoretical knowledge and practical application, helping students understand the real-world relevance of their technical fields.

STEM teaching and class management, as observed in TVETMARA classes, reveals a variety of strategies that educators use to balance content delivery, ICT integration, and student engagement. The evidence from the class observations highlights how educators demonstrate mastery in their respective fields while incorporating ICT tools to support learning. Each educator adopts a distinct approach to managing their classroom and enhancing STEM learning outcomes.

For example, X1 effectively manages his class by employing inquiry-based learning and scaffolding techniques. His use of Google Meet and YouTube videos to demonstrate complex engineering concepts, such as engine types, aligns with STEM principles. The use of video content makes abstract concepts more tangible for students, and his active engagement—constantly asking students for feedback—demonstrates an adaptive management style. This approach encourages open discussion, fostering a collaborative and inquiry-driven learning environment.

In contrast, X7 adopts a more traditional, teacher-centered approach, though he does integrate inquiry-based elements into his lessons. His management style focuses on structured content delivery using Microsoft Teams and PowerPoint presentations, which help maintain class organization and ensure clear communication of learning objectives. While there is less interaction compared to X1, the controlled and structured method ensures students remain on track, particularly when dealing with regulatory and theoretical content.

Similarly, X9 structures his theoretical lessons with a gradual increase in complexity, moving from easy to difficult concepts. This flow helps students grasp abstract concepts, especially in engineering topics like structural steel. His use of visual presentations and videos to illustrate complex structures supports STEM learning by visually reinforcing difficult topics, while the gradual lesson progression ensures effective class management.

X5 stands out with a strong focus on student-centered learning, adapting to the diverse ICT needs of his students. In his IoT class, he uses simulators like Arduino and Matlab to bridge theory and practice. By understanding his students' varied technological backgrounds, X5 not only delivers content but also manages the classroom dynamically,

allowing students to learn at their own pace. This inclusive approach exemplifies a more personalized and adaptive management strategy.

Across these observations, it is evident that STEM teaching in TVETMARA is supported by a blend of traditional and innovative class management techniques. Educators tailor their teaching and class management based on the nature of the content, the tools available, and their students' needs, ensuring a balanced and effective learning environment.

The interdisciplinary approach in the lesson plans is well-integrated, allowing students to connect theoretical knowledge with real-world applications. In the LP4 lesson, students learn about ‘atomic structures, bonding, and material properties’, combining concepts from chemistry, physics, and engineering. The use of videos to explain atomic bonding helps students visualize abstract concepts and understand their relevance in material science. This combination of disciplines not only enriches the learning experience but also ensures that students grasp the broader context of how materials behave in engineering applications.

In the LP2 lesson, the integration of CAD with engineering theory illustrates another interdisciplinary approach. By using AutoCAD, students apply engineering concepts directly to CAD, blending technical drawing with theoretical understanding. This ensures that students develop both the practical skills needed in industry and the theoretical foundation required to make informed design decisions. The interdisciplinary nature of these lessons deepens student learning by showing how different fields work together in solving real-world engineering problems.

Class management across the lesson plans is well-executed, with each instructor using technology to maintain engagement and structure. In LP1, the use of PowerPoint slides, videos, and real-time interaction through exercise sheets keeps students focused and ensures a smooth flow of instruction. The combination of visual aids and practical tasks provides clear direction, helping the instructor manage the class effectively while keeping students actively engaged.

In the LP4 lesson, Microsoft Teams plays a key role in class management, allowing the instructor to lead discussions, share resources, and facilitate real-time questions. The inclusion of WhatsApp group notes further supports class management by ensuring that students have access to critical information outside of the lecture, enhancing communication. This use of digital tools ensures that students stay connected and organized, especially in a remote learning environment. The structured use of multimedia, combined with active class participation, reflects strong management strategies across all lesson plans.

The information on this theme helped with the development of construct Pedagogical Practices in the instrument phase of the study. Table 4.2.4 presents the codes related to the Pedagogical Practices constructed in the STEM ICT Teaching Inventory and excerpts from data sources.

Table 4.4: Theme Pedagogical Practices Facilitate Development of Pedagogical Practices Construct

Codes	Description	Statements/Terms represent- extracted from interview transcripts	Class observations	Lesson Plan	TPACK Domain
STEM teaching	ICT tools support the integration of cross disciplines and represent real life situation	context of Geometrical Construction, dimensioning, detect potential design flaws, drawing editing, role play projects	Observed	Documented in BCoS	PCK, TPK, TCK
Class Management	ICT tools support effective students' learning	Recording classes, on time online work submission by students, various students learning abilities with ICT,	Observed	Documented in BCoS	PK, TPK

4.2.5 Theme 5: Lesson Preparations

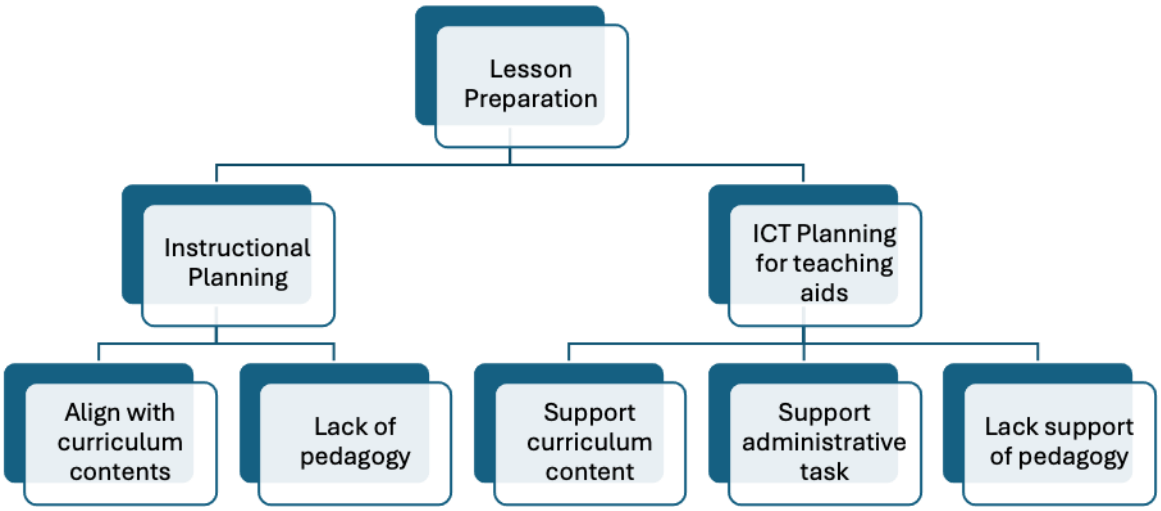


Figure 4.6: Concept Map for Theme 5

Educators' choices strongly influence the success of ICT integration in teaching and learning and the instructional design of their lessons. Thus, how educators plan their lessons becomes a critical factor in determining the effectiveness of ICT implementation in the classroom (Janssen et al., 2019; König et al., 2015). It requires a profound understanding of the subject, the unique needs of students, and the availability and functionality of technological tools (Ghavifekr & Rosdy, 2015; Janssen & Lazonder, 2015; König et al., 2015). Integrating technology into teaching goes beyond merely selecting relevant tools; educators must also adapt their use of technology to different situations and instructional goals to enhance the learning process effectively. Additionally, teachers' knowledge, beliefs, and classroom performance impact their ability to successfully integrate ICT into lesson planning, demonstrating a symbiotic relationship between their skills and professional success (Ghavifekr & Rosdy, 2015).

According to the qualitative findings of this study, integrating information and communication technology (ICT) in STEM teaching requires two fundamental activities during lesson preparation. These activities include instructional planning and ICT planning for teaching aids that support STEM teaching. Educators are responsible for developing quality instructional learning activities through a well-structured lesson plan (Nurtanto et al., 2021; Purwinda Anggrella et al., 2023). Lesson plans act as an instructional guide for a class session, outlining specific learning objectives and associated subject matter. This allows for clear learning outcomes that students are expected to achieve.

Additionally, these plans detail the teaching and learning process, including the learning activities and methodologies and the necessary resources like study materials and technology (Janssen & Lazonder, 2015). Therefore, adequate lesson preparation is crucial in integrating technology into classroom instruction. The thoughtful coordination of instructional design and ICT teaching aids is essential for optimising technological advancements in STEM teaching.

Through an analysis of four lesson plans, TVETMARA educators have meticulously aligned subtopics with the curriculum goals of their respective courses, ensuring a coherent structure that facilitates students' comprehension. For instance, within the X9 lesson plan addressing the topic "Structure of Materials," the content was partitioned into four distinct subtopics representing four interrelated concepts: Atom Arrangement in Materials, Basic Structure of Materials, Atomic Bonds, and Crystal Structure of Materials.

Each subtopic is structured to foster a robust foundation of understanding, with clearly defined learning outcomes that serve as student progress benchmarks. The lesson

plan's execution unfolds over four sequential phases: Introduction, Development, Summary, and Evaluation. This progression guides X9 in the implementation of STEM teaching within the classroom.

Furthermore, the discussion within the lesson is framed around real-world workplace problems, enhancing students' ability to grasp and contextualise the concepts. Nevertheless, reviewing the plan reveals a predominantly teacher-centred approach, with an apparent absence of student-centred activities to engage students actively.

Despite this limitation, X9 leverages Information and Communication Technology (ICT) tools, such as video and slide presentations, to supplement STEM instruction. The visual depiction of concepts, such as the atomic arrangement in materials, plays a pivotal role in engaging students within the lesson's framework. Observations conducted during classroom sessions confirm X9's fidelity to the lesson plan, including utilising multimedia resources. This approach facilitated students' engagement with the content, grounding their understanding of the concepts through a connection to real workplace scenarios. The seamless integration of visual aids, even without student-centred activities, showcases the adaptability and effectiveness of modern teaching tools within a well-structured curriculum.

Lesson planning helps educators lead high-quality classroom instruction (Latifa, 2017). Most interviewees agreed that adequate lesson preparation greatly contributes to the smooth delivery of lessons. Moreover, a structured lesson plan assists educators in adapting learning to curriculum content (Purwinda Anggrella et al., 2023). For instance, one participant, X5, highlighted the importance of aligning his slides with the course syllabus in his teaching process. He said that:

> I meticulously prepare slides that align with the syllabus as part of my teaching process. These slides are valuable teaching materials, providing a comprehensive overview of the subject matter. To ensure easy access for my students, I upload these teaching materials on Microsoft Teams, our designated platform for academic collaboration.
>
> (X5)

X5's commitment to delivering high-quality teaching experiences is evident in his structured and organised approach to lesson preparation. This is particularly important in STEM teaching, where a structured learning environment is essential to build a solid foundation for complex concepts that integrate science, technology, engineering, and mathematics. By logically structuring the slides, X5 ensures that students can easily follow and understand the information presented.

Moreover, the class observation of X5 highlighted the importance of planning a structured learning environment in STEM teaching (Widayanti et al., 2019). X5 effectively taught complex concepts by using well-prepared and logically structured slides. With ThingSpeak as a prototype to demonstrate the analytics concepts of IoT (Pasha, 2016), he created a solid foundation for understanding. Additionally, he successfully integrated students' prior knowledge to enhance their learning experience. This approach enhanced his students' comprehension and fostered their enthusiasm for learning, making the technical and engineering subject matter more approachable and engaging. The integration of ICT tools by X5 to teach IoT using ThingSpeak demonstrates how proper planning of ICT can facilitate effective teaching.

By aligning slides with the syllabus, X5 demonstrates the integration of ICT in the lesson planning process, leveraging technology to present information in a visually engaging and organised manner. This fosters an interactive learning experience for students, allowing them to interact with the materials, ask questions, and seek clarification during or after the class. The convenience of having the materials on Microsoft Teams further supports student learning by enabling them to review and study the slides at their own pace while also facilitating real-time engagement and concept reinforcement during class sessions.

Another participant, X7, followed a similar approach in planning effective instruction for her architectural class. She created slides for each topic and allocated 2 to 3 weeks to cover each unit. X7 carefully aligned the content of the slides with the corresponding syllabus and learning outcomes, ensuring that her instruction remained relevant and in line with the overall learning goals of the course. The strategic sequencing of topics allowed for the logical introduction of new ideas while building upon previously learned concepts (Nurtanto et al., 2021). By allocating adequate time for each unit, X7 ensured comprehensive content coverage without rushing through essential concepts.

The findings from the qualitative analysis of X5 and X7 highlight the importance of effective lesson preparation in integrating ICT into STEM teaching. Using well-structured teaching materials and appropriate ICT tools enhances communication and knowledge exchange between TVETMARA educators and their students, leading to more engaging and compelling learning experiences. Hence, by aligning lesson materials with the course syllabus and learning objectives in the TVETMARA curriculum, its educators can create a cohesive and coherent learning environment that promotes students' understanding and mastery of complex STEM concepts.

The development of lesson plans in STEM teaching necessitates careful deliberation, including the strategic incorporation of Information and Communication Technology (ICT) tools to cultivate a conducive educational atmosphere (Kamal et al., 2023; Nurtanto et al., 2021; Widayanti et al., 2019). An evaluation of X4's lesson plan for her Computer-Aided Design (CAD) class illuminates her intentional deployment of various ICT tools in every stage of her pedagogical blueprint.

Beginning with the introductory phase, X4 integrates an 'e-attendance' system to log student presence, immediately exemplifying the role of ICT in class management. As the lesson progresses, X4 consistently relies on slide presentations as a medium of instruction during the induction set and the development of the lesson, thereby enhancing auditory and visual comprehension of the topic. Interestingly, X4 leverages a specialised ICT tool—AutoCAD software for topic demonstration. This deliberate choice signals her intent to provide students with practical experience using an industry-standard application. The concluding phase of the lesson is also infused with ICT, as X4 uses the Quizizz platform to evaluate student understanding—an engaging and informative assessment tool. Further, she employs Microsoft Teams to disseminate information sheets and task assignments, illustrating how ICT can streamline class communication and organisation.

Despite these efforts, X4's approach to ICT integration in her CAD class must also be revised. There still needs to be more utilisation of ICT to bolster her pedagogical practices in STEM teaching. Her use of ICT, while demonstrably valuable in presenting relevant concepts and managing administrative tasks, needs to fully exploit the potential of ICT to enhance the learning process and support educational goals. As such, this indicates a potential area for further development and underscores the importance of comprehensive planning when integrating ICT tools in STEM teaching.

Teaching aids are crucial in teaching and learning, especially for STEM teaching. Teaching aids such as visual representations, simulations and models can help explain complex technical and engineering concepts in a more accessible and understandable manner(Ahmad Zaki et al., 2018; Ha & Fang, 2013; Zulkifli et al., 2022). They provide students with a concrete representation of abstract ideas and facilitate comprehension. Students can better conceptualise the relationships between different elements when they see and manipulate representations of these concepts. This creates a more profound understanding for a strong foundation for further learning and problem-solving. Most participants use images, videos and PowerPoint slides to create visual representations. They planned how the teaching aids could assist in explanation in the class. For example, X7 shared how she prepared her presentations in class. She said that:

> Given the subject matter, I recognise the importance of visual aids for effective learning. Therefore, I incorporate relevant images into my slides, particularly when teaching about building structures. These visual elements enable students to visualise better and understand the concepts being taught.
>
> (X7)

X7's approach to planning teaching aids exemplifies the importance of leveraging visuals to facilitate effective learning. She demonstrates a thoughtful and strategic use of visual aids to enhance the learning experience for her students, mainly when teaching about building structures. By aligning visual aids with the subject matter and considering their impact on student understanding and engagement, she ensures that her students receive a more comprehensive and meaningful learning experience, particularly when studying complex topics like building structures.

Her decision to incorporate relevant images into her slides is well-aligned with the content she is teaching about building structures. Visual aids can be particularly beneficial in conveying architectural designs, construction processes, and spatial relationships. Building structures can be abstract and challenging to visualise solely through verbal explanations. Using visual aids, such as diagrams, sketches, or photographs of buildings, X7 enables students to form mental images and better comprehend architectural concepts.

Overall, X7's thoughtful and strategic use of visual aids fosters better understanding and enhances student engagement (Zulkifli et al., 2022). By tapping into the power of visuals to complement her lessons on building structures, she provides her students with a more tangible and immersive learning experience, making the subject matter more accessible and relatable.

Nevertheless, the development of ICT tools for educational assistance necessitates a systematic and intentional approach to ensure the effective use of technology in enhancing the teaching and learning experience.

ICT as a teaching aid for STEM teaching enhances the learning journey, encourages active engagement, and prepares students for the technology-driven world (Mbarika et al., 2010). The incorporation of ICT as teaching aids in STEM teaching has the potential to transform the learning experience, empower students, and better equip them for the challenges and opportunities in the modern world. This integration allows TVETMARA educators to foster a more captivating and efficient learning setting, nurturing a cohort of proficient individuals in technical and engineering domains.

The significance of utilising digital platforms to share teaching materials is apparent in how TVETMARA strongly emphasises digitalisation within its educational

landscape. By embracing platforms like Microsoft and Google Classroom, TVETMARA educators can cater to different learning styles, promoting better engagement and comprehension through various content formats, including videos and interactive quizzes. This approach fosters a supportive and inclusive learning environment, empowering students to take ownership of their learning process (Adi Badiozaman et al., 2022; S. Ismail & Ismail, 2021). Moreover, for TVETNMARA educators, this practice allows for more effective use of class time and facilitates meaningful interactions with students during class discussions and activities.

TVETMARA educators increasingly recognise the importance of using digital platforms to share teaching materials before class, as it offers various advantages that optimise the learning experience. Pre-sharing materials enhance preparedness among students, enabling them to familiarise themselves with upcoming topics, concepts, or readings. This preparatory engagement sparks initial interest and cultivates a foundation for meaningful classroom discussions and interactions. X2 and X6 are examples of how most TVETMARA educators practice sharing teaching resources digitally before teaching classes. For instance, X2 uses Google Classroom (GC) to share lesson information sheets, recorded discussions, and videos to help students understand more advanced concepts like overhead lines and underground topics. He said that:

> Since last semester, I have been using Google Classroom (GC) to share lesson information sheets with my students, and I will continue doing so in the current semester. The recorded discussions and videos help them to understand especially more advanced concepts such as overhead lines and underground.
>
> (X2)

This pre-sharing of lesson materials optimises the learning experience by enabling students to come prepared and actively participate in discussions. The inclusion of multimedia content caters to different learning styles, benefiting visual and auditory learners while allowing others to review materials at their own pace.

Similarly, X6 shares lesson plans and class recordings of the Electrical Act and Regulations with his students, breaking down complex concepts into digestible segments. He utilises Microsoft Teams to support online teaching, incorporating slide presentations with real-world examples to enhance comprehension and retention. Through these digital practices, TVETMARA educators foster an enriched educational environment that empowers students and promotes effective learning.

This emphasises that while lesson plans serve as powerful tools to streamline the use of technology in classrooms, the support resources attached to these plans should cater to the unique requirements of each teacher (Dewi et al., 2019; Janssen & Lazonder, 2015; König et al., 2022). This tailored approach can significantly enhance the efficiency and effectiveness of ICT integration in education, ultimately contributing to more enriched and engaging learning experiences.

In summary, the successful integration of Information and Communication Technology (ICT) in teaching and learning depends on the thoughtful decisions made by educators in designing their instructional plans. This process entails a comprehensive understanding of the subject matter, individualised student needs, and the suitability of technological tools. The effective incorporation of technology in the classroom goes beyond mere tool selection; rather, it necessitates the adaptation of ICT to various teaching situations and learning objectives to optimise the educational experience.

The X4, X5, X7, X2, and X6 case studies at TVETMARA exemplify the positive impact of strategic ICT integration in STEM teaching. X5's alignment of subtopics with the curriculum goals and X7's effective use of visual aids demonstrate how careful planning can enhance comprehension and engagement in complex subjects. Moreover, as employed by X2 and X6, digital practices contribute to a supportive learning environment and encourage students to take responsibility for their education.

While these examples illustrate the potential benefits of ICT integration, they also highlight areas for further development. For instance, X4's CAD class showed promise in utilising various ICT tools but could benefit from further exploration and integration to optimise pedagogical practices.

To foster a genuinely enriching educational environment, institutions like TVETMARA must continue prioritising digitalisation and embracing platforms catering to diverse learning styles, such as Microsoft and Google Classroom. Tailoring lesson plans to suit individual teachers' preferences and needs is also essential to maximise the efficiency and effectiveness of ICT integration in education.

Thus, the success of ICT integration in teaching and learning lies in the collaborative efforts of educators, administrators, and institutions to leverage technology effectively while considering the unique requirements of their students and subjects. Educators may better prepare students for success in a digital environment by continually improving their instructional design and using the potential of ICT technologies.

In instructional planning for ICT-based teaching aids, TVETMARA educators consider not only the content but also the effective integration of ICT to enhance student engagement and learning outcomes. The use of ICT as part of instructional planning was

evident in several classes, such as in X1's automotive engineering course, where ICT tools like Google Meet and YouTube were employed to scaffold inquiry-based learning. His approach demonstrates the importance of planning for technology that allows real-time interaction and problem-solving, aligning with the lesson objectives while engaging students in discussions. The deliberate use of video to demonstrate engine types reflects a thoughtful integration of ICT into content delivery, though a deeper level of technology knowledge would enhance his TPACK (Technological Pedagogical Content Knowledge) application.

Similarly, X7s teaching strategy in the Electrical Act and Regulations class used PowerPoint presentations and Microsoft Teams to support online learning. The planning here centred on the use of ICT tools to visually present information. Although the theory-heavy content was delivered through a teacher-centred approach, X7 incorporated inquiry-based techniques to involve students. This mix illustrates the need for thoughtful instructional design where ICT serves not only as a means of content presentation but also as a tool to foster engagement.

The need of lesson preparation is further emphasized by X4, a computer-aided design (CAD) instructor. Using AutoCAD software, she skilfully integrated content, pedagogy, and technology. She included ICT resources that catered to students' auditory, visual, and kinaesthetic demands into her courses, which aimed to transition them from manual to digital drawing. Students were able to study at their own speed because to this extensive use of ICT, which highlights the need of lesson design that takes into account a variety of teaching tools and diverse learning styles.

However, ICT planning goes beyond selecting appropriate tools. It requires a clear alignment with course outcomes, as seen in X9’s theoretical steel structure class. His use of

Microsoft Teams and PowerPoint for content presentation, coupled with video, allowed abstract concepts to be visualized. Yet, the limited range of ICT tools suggests room for further planning to explore more interactive technologies that could deepen student understanding and foster engagement.

In summary, the observed participants' approaches reflect varying degrees of success in instructional and ICT planning. Thoughtful integration of ICT enhances the teaching process, but the planning must also consider the depth of interaction and student engagement that technology can facilitate. From basic tools like video and PowerPoint to more advanced software like AutoCAD, the choice of ICT must align with both instructional goals and the diverse needs of students. This requires ongoing planning, reflection, and adaptation to ensure that ICT serves as a meaningful component of the teaching strategy, rather than a mere supplement to traditional methods.

The instructional planning in the lesson plans is carefully designed to ensure a balanced approach to teaching complex concepts. In the LP1 lesson plan, the instructor uses scaffolding, gradually introducing students to first-order circuits before progressing to more complex differential equations. The lesson is divided into clear phases, with theoretical explanations followed by practical problem-solving exercises. This structured approach helps students build confidence in understanding abstract concepts before applying them in practical contexts. The use of exercise sheets for problem-solving further reinforces the instructional planning by giving students hands-on experience.

In LP2, the instructional planning focuses on both the theoretical understanding of dimensioning techniques and their direct application in AutoCAD. The lesson is segmented into instruction and practice, ensuring that students receive detailed explanations before they work on real-time CAD projects. This balance between theory and application is

crucial for student success, as it prepares them for industry standards. By including formative assessments like quizzes, the instructor ensures that students can monitor their own progress and receive immediate feedback, strengthening the instructional flow.

The ICT planning for teaching aids is equally robust across the lesson plans, with technology playing a central role in enhancing student engagement. In LP3, the use of PowerPoint slides, LCD projectors, and videos aligns well with the lesson objectives. These tools are chosen to simplify complex circuit theories and provide visual reinforcement. The integration of multimedia not only caters to different learning styles but also ensures that students can visualize abstract concepts like energy storage and transient states. The ICT aids effectively support the teaching of theoretical content, making it more accessible to students.

In the LP4 lesson, the ICT planning includes Microsoft Teams, videos, and WhatsApp group notes, ensuring that students have multiple touchpoints for accessing information. Videos explaining atomic structures and bonding are especially useful in breaking down difficult concepts, while Microsoft Teams facilitates live interaction. The addition of WhatsApp notes provides a continuous line of communication and reinforces the content outside the classroom. These ICT tools are selected to ensure that learning remains interactive, even in a virtual environment, and that students are supported at every stage of their learning process.

The information of this theme helped develop the construct of Lesson Preparation in the instrument phase of the study. Table 4.2.5 presents the codes related to the Lesson Preparation construct in the STEM ICT Teaching Inventory and excerpts from data sources.

Table 4.5: Theme Lesson Preparation Facilitates Development of Lesson Preparation Construct

Codes	Description	Statements/Terms represent- extracted from interview transcripts	Class observations	Lesson Plan	TPACK Domain
Instructional Planning	ICT tools support the integration of cross disciplines and represent real life situation	Preparing lesson plan, preparing PowerPoint slides, organizing based on topics in syllabus/objective and learning outcomes, preparing video passed on field regulations, using images in internet to visualize,	Observed	Documented in BCoS	PCK, TPK, TCK
ICT Planning for teaching aids	ICT tools support effective students' learning	Sharing/uploading digital materials before class using Microsoft/Google,	Observed	Documented in BCoS	PK, TPK

4.3 Instrument Development (Phase 2)

The instrument development phase was a major interface between the qualitative and quantitative strands. After analyzing the qualitative findings, the instrument development process consisted of three components: a) using themes from the qualitative analysis to develop dimensions, b) using codes to describe the dimensions and c) using codes and quotes to generate items.

The first step was to use the qualitative themes to identify the dimensions of the instrument. Table 4.6 shows the aligning of qualitative findings and instrument dimensions. For example, for Theme 1, Qualitative Theme ICT Selection aligns with Dimension 1 ICT Selection.

Table 4.6: Aligning The Qualitative Theme and Instrument Dimension

No. of Theme	Qualitative Themes	No. of Dimensions	Qualitative Dimensions from Themes
Theme 1	ICT Selection	Dimension 1	ICT Selection
Theme 2	Organisation Support	Dimension 2	Organisation Support
Theme 3	Peer Collaboration	Dimension 3	Peer Collaboration
Theme 4	Pedagogical Practices	Dimension 4	Pedagogical Practices
Theme 5	Lesson Preparations	Dimension 5	Lesson Preparations

Table 4.7 shows the aligning of qualitative codes with instrument dimensions description. The subsequent procedure included using qualitative coding to articulate the many characteristics of the STEM ICT Teaching Inventory. Two qualitative codes emerged in the qualitative subject of ICT Selection: Curriculum Goals and Teaching Strategies. ICT Selection is defined as selecting information and communication technology tools and resources in alignment with the aims and teaching methods of the TVETMARA curriculum - **ICT selection based on TVETMARA curriculum goals and teaching method.** Three codes were utilised in the qualitative subject of Organisational Support: ICT based on course requirements, Digitalisation program, and ICT training. Therefore, the dimension is be defined as the level of assistance provided by an organisation in terms of offering suitable teaching and learning facilities for information and communication technology (ICT), as well as giving training in ICT pedagogy - **support given by the organisation in providing teaching and learning facilities of ICT that are conducive and ICT pedagogical training.** The theme of peer cooperation has three quotes: "**Discussion with colleagues**," "**Collaboration with students**," and "**Collaboration with technical staff**." The concept of Peer Collaboration pertains to the act of collaborating with other TVETMARA Educators in the development of digital teaching materials, as well as engaging in collaborative efforts with students and technical groups to assist in troubleshooting - **refers to collaboration with peers of MARA TVET Educators in developing digital teaching materials and collaboration with students and technical group to assist in troubleshooting**. The dimension of Pedagogical Practices encompasses the concepts of '**STEM teaching**', '**Class management**', and '**Assessment**'. These terms are used to characterize the use of information and communication technology (ICT) in STEM-related pedagogical practices - **refers to ICT**

usage in pedagogical practices of STEM teaching that includes integration and cross disciplines, as well as the use of ICT in class management to support learning effectively. This includes the integration of ICT across different disciplines and the use of ICT in managing the classroom to enhance effective learning. Qualitative codes such as "**Lesson Preparation**" and "**Curriculum Goals and Technology**" were identified under the theme of Lesson preparation. Lesson preparation is defined as the process undertaken by educators in the TVETMARA system to develop instructional plans and digital teaching and learning resources - "**refers to TVETMARA educators' preparation of instructional planning and digital teaching and learning materials based on TVETMARA curriculum, students' readiness, teaching strategies and ICT facilities provided by organisation"**. This preparation is based on several factors, including the TVETMARA curriculum, students' preparedness, the chosen teaching methodologies, and the organisation's available ICT facilities.

The third step was using codes and quotes from the interview's excerpts to generate the items in each dimension. In this step, the researcher relied on codes and direct quotes from participants to develop items. In Table 4.8, Dimension 1: ICT Selection, direct quotes from the participants were summarised to reflect the learning outcomes in Item 1. In Item 2 to Item 10, direct quotes from participants were utilised to represent best practices in teaching strategies used in TVETMARA.

Table 4.7: Aligning The Qualitative Codes and Instrument Dimension Description

Qualitative Themes	Qualitative Codes	Quantitative Dimensions from Themes	Dimension Description
ICT Selection	- Curriculum goals - Teaching Strategies	ICT Selection	This dimension refers to ICT selection based on TVETMARA curriculum goals and teaching method.
Organisation Support	- ICT based on courses needs - Digitalization programme - ICT training	Organisation Support	This dimension refers to support given by organization in providing teaching and learning facilities of ICT that are conducive and ICT pedagogical trainings.
Peer Collaboration	Discussion with colleagues Collaborate with students Collaborate with technical staff	Peer Collaboration	This dimension refers to collaboration with peers of MARA TVET Educators in developing digital teaching materials and collaboration with students and technical group to assist in troubleshooting.

Table 4.7 Continued

Pedagogical Practices	STEM teaching Class management Assessment	Pedagogical Practices	This dimension refers to ICT usage in pedagogical practices of STEM teaching that includes integration and cross disciplines as well as used of ICT in class management to support learning effectively.
Lesson Preparations	Lesson Preparation Curriculum goals and technology	Lesson Preparations	This dimension refers to TVETMARA educators' preparation of instructional planning and digital teaching and learning materials based on TVETMARA curriculum, students' readiness, teaching strategies and ICT facilities provided by organisation.

Table 4.8: Aligning The Qualitative Codes/Quotes and Items in Dimension 1

Quantitative Dimensions	Qualitative Codes	Qualitative Quotes	Items Generation
ICT Selection	Curriculum goals	AutoCAD fundamental for engineering drawing, inventor upgraded drawing from 2d to 3d, troubleshoot, simulator, basic engineering, advanced technology, Arduino, online software	I select ICT which aligns with my learning outcomes.
ICT Selection	Teaching strategies	online class, theory class, practical class, demonstration, hands-on, problem based, project based, learning outcomes, two-way communication, inquiry based, grouping, case study	I select ICT which aligns with my teaching methods in Theory class. I select ICT which aligns with my teaching methods in Practical class. I select ICT which aligns with my teaching method (demonstration). I select ICT which aligns with my teaching method for hands-on. I select ICT which aligns with my teaching method. (Problem-based learning). I select ICT which aligns with my teaching method (project-based learning). I select ICT which aligns with my teaching method (inquiry-based learning). I select ICT which aligns with my teaching method (group learning). I select ICT which aligns with teaching method (case study).

Table 4.9, Dimension 2: Organization Support, code 'ICT devices based on course needs' were refined into three aspects, which were TVETMARA course syllabus need, technical field needs and industry needs. These three aspects were used to develop Item 1 – Item 3 in Dimension Organisation support. In the code 'Digitalization Programme', direct quotes from the participants were used to write the item 'My organisation provides sufficient lab facilities' and 'My organisation provides digital teaching materials (e.g. e-module)'. Direct quotes from the participants in code' ICT training' represented three components in Item 6 – Item 8: ICT knowledge, content knowledge and pedagogical knowledge.

In Table 4.10, Dimension 3: Peer Collaboration, based on code 'Discussion with colleagues' and participants' direct quotes, were used to generate Item 1 – Item 5. For Item 6, the direct quote 'students assisting their peers with technical problems (installing software used in class)' was refined to 'I collaborate with students' apprentice to assist students to solve technical problems (e.g. installing software, wifi).'.Direct quote 'troubleshooting – technician assistance to help students with technical problems, preparing software used for online class' was summarised as 'I collaborate with peers from technical group to assist with technical problems (e.g. installing software, wifi).'

In Table 4.11, Dimension 4: Pedagogical Practices, based on direct quotes in code 'STEM teaching', Item 1- Item 3 were developed. For example, the direct quote 'using videos and images from the internet to show real life/workplace situations' was refined to two items: Item 1 – I use videos from the internet to show real life/workplace situations and Item 2 – I use images from internet to show real/workplace situations. In code' Class Management', an example of direct quote 'recording classes' was written as Item 4 -I use

ICT to record my classes(theory/practical). Another example of a direct quote, 'taking students attendance', was written as Item 5 – I use ICT to record my students' attendance.

In Table 4.12, Dimension 5: Lesson Preparations, based on direct quotes in code 'Lesson Preparation', Item 1, Item 3, Item 6 – Item 8 were developed. For example, the direct quote 'I design lesson plan..' was refined to Item 1: Item 1 – I design my daily lesson plan that integrates ICT in STEM teaching. Another example from the direct quote, 'I meticulously prepare slides that align with the syllabus.' was written as Item 3 -I design my PowerPoint slides based on my learning outcomes in STEM teaching. From direct quotes in code' curriculum goals and technology', 'If I cannot show it in real life situations, I will use images… videos', two items were developed – Item 4 – I design images using ICT to demonstrate complex ideas in STEM teaching and Item 5- I design images using ICT to visualise learning contents that difficult to observe explicitly in STEM teaching.

In the study, based on the qualitative findings, initially there were five constructs were generated to measure the STEM teaching practices integrating ICT by TVET MARA teachers. The item generation steps included converting qualitative themes to constructs and quotes to items adapting from Creswell and Plano Clark’s instructions of instrument development.

Table 4.9: Aligning The Qualitative Codes/Quotes and Items in Dimension 2

Quantitative Dimensions	Qualitative Codes	Qualitative Quotes	Items Generation
Organisation Support	ICT devices based on courses needs	software license upgraded, Microsoft license	1.My organisation provides ICT based on TVET MARA course syllabus needs. 2.My organisation provides ICT based on technical field needs. 3.My organisation provides ICT which aligns with industry needs.
Organisation Support	Digitalization programme	allocating budgets for ICT devices and smart class, buying teaching materials and devices based on fields (electrical, automotive, mechanical etc), preparing smart labs	4.My organisation provides sufficient lab facilities. 5.My organisation provides digital teaching materials (eg e-module).
Organisation Support	ICT training	how to use Google classroom and Teams for online classes, Microsoft training, competency test for AutoCAD	6.My organisation provides ICT training to enhance ICT knowledge. 7.My organisation provides ICT training to enhance content knowledge. 8.My organisation provides ICT training to enhance pedagogical knowledge.

Table 4.10: Aligning The Qualitative Codes/Quotes and Items in Dimension 3

Quantitative Dimensions	Qualitative Codes	Qualitative Quotes	Items Generation
Peer Collaboration	Discussion with colleagues	developing videos for demonstration needs, using YouTube channel to upload teaching materials, sharing sessions for upgrading ICT skills	1. I develop videos for hands-on class with TVET MARA peers. 2. I develop PowerPoint slides for STEM teaching with TVET MARA peers. 3. I develop pictures and images for STEM teaching with TVET MARA peers. 4. I share STEM teaching digital materials with TVET MARA peers. 5. I share STEM teaching digital assessment materials with TVET MARA peers.
Peer Collaboration	Collaborating with students	students assisting their peers with technical problems (installing software used in class)	6. I collaborate with students' apprentice to assist students to solve technical problem (eg installing software, wifi).
Peer Collaboration	Collaborating with technical group	troubleshooting – technician assistance to help students with technical problems, preparing software used for online class	7. I collaborate with peers from technical group to assist with technical problems (eg installing software, wifi).

Table 4.11: Aligning The Qualitative Codes/Quotes and Items in Dimension 4

Quantitative Dimensions	Qualitative Codes	Qualitative Quotes	Items Generation
Pedagogical Practices	STEM teaching	using videos and images from internet to show real life situation, computer aided design, integrating cross disciplines (mathematics, science, technology)	1. I use videos from internet to show real life/ workplace situations. 2. I use images from internet to show real life/workplace situations. 3. I use computer aided design to show real life/workplace situations.
Pedagogical Practices	Class management	recording classes, on time online work submission by students, taking students attendance, Wi-Fi accessibility for students, various students learning abilities with ICT, using class point to monitor students	4. I use ICT to record my classes (theory/practical). 5. I use ICT to record my students' attendance. 6. I use ICT for submission of my students' work. 7. I use ICT to differentiate my students' learning styles. 8. I use ICT based task for my students' assessment. 9. I use ICT to conduct my students' evaluation. (eg Microsoft/Google form/quizizz/liveworksheet).

Table 4.12: Aligning The Qualitative Codes/Quotes and Items in Dimension 5

Quantitative Dimensions	Qualitative Codes	Qualitative Quotes	Items Generation
Lesson preparation	Lesson preparation	using videos and images from internet to show real life situation, computer aided design, integrating cross disciplines (mathematics, science, technology), uploading information sheet	1. I design my daily lesson plan that integrates ICT in STEM teaching. 3. I design my PowerPoint slides based on my learning outcomes in STEM teaching. 6. I install computer design software before STEM teaching. 7. I upload my teaching digital materials before STEM teaching. 8. I share website link with students before STEM teaching.
Lesson preparation	Curriculum goals and technology	Preparing video based on field regulations, using images in internet to visualize	2. I develop my own video for STEM teaching. 4. I design images using ICT to demonstrate complex ideas in STEM teaching. 5. I design images using ICT to visualize learning contents that difficult to observe explicitly in STEM teaching.

4.3.1 Expert Review (Content Validation)

After the item generation, SITI was tested for content validation. The content validation process was carried out using the Content Validity Ratio (CVR) method to assess how effectively the required components reflected indicators of teaching practices in STEM education through ICT, specifically among TVETMARA educators. Drawing on Yusoff's (2019) approach to content validation, a pool of 42 items was distributed to experts in instructional technology who have published and worked extensively in the field. These experts were asked to evaluate the relevance and quality of each item. Invitations were sent by email to four individuals with recognized expertise. However, only two accepted the invitation, while the other two declined due to time constraints. Despite this, two expert reviewers were deemed sufficient for the content validation process, as supported by Doğan et al. (2022).

Both Expert 1 and Expert 2 are specialists in instructional technology. Expert 1, an associate professor at a public university, focuses on human-computer interaction (HCI) and mobile learning. Expert 2, with over two decades of experience, is actively engaged in educational training and workshops. Her latest project, e-Mundus +, was funded by Erasmus Mundus and the European Union to promote equity and access to higher education through open and distance learning. The review based on Expert 1 and Expert 2 aimed to assess the content validation of SITI in measuring the integration of ICT into STEM teaching within TVETMARA institutions.

The STEM ICT Teaching survey consisted of 42 items developed from qualitative findings. Each expert panel member was asked to assess the necessity and sufficiency of each item in representing different aspects of the construct using a 5-point Likert scale,

ranging from "Poor Measure" to "Excellent Measure." Experts were also invited to provide feedback on the clarity of the items.

Expert Review SITI (Appendix M) were analyzed using percentages, mean calculations, and the Content Validity Index (CVI). The degree of consensus among the experts for each item—whether high, medium, or low—was determined by comparing the percentage and mean values. Before calculating the CVI, relevance ratings were recoded as 1 for ratings between 3 and 5 and 0 for ratings between 1 and 2. The CVI was then calculated using Excel. The STEM ICT Teaching Inventory included five constructs and 42 items. Only items that received a minimum of 70% agreement and a CVI of 1 were retained for further analysis.

The results from Table 4.13 provide a detailed analysis of the evaluation of the STEM ICT Teaching Inventory (SITI) based on the Content Validity Index (CVI). This table reflects how well individual items within the inventory were judged by expert reviewers in terms of their necessity and sufficiency in representing different aspects of STEM teaching through ICT. The five key domains assessed are ICT selection, pedagogical practices, lesson preparation, peer collaboration, and organization support.

4.3.1.1 ICT Selection

All items within this domain received a 90% agreement rate, a mean score of 4.50, and a CVI of 1.00. This suggests that the experts unanimously agreed that the ICT tools chosen by educators aligned well with various teaching methods, including theory, practical, and inquiry-based learning. Every item in this domain was retained, indicating a high level of consensus on the relevance of ICT selection to STEM teaching practices.

4.3.1.2 Pedagogical Practices

In Pedagogical Practices, items under this domain also performed well, with most achieving 90% agreement, a mean score of 4.50, and a CVI of 1.00. These items focus on how educators use ICT to enhance teaching, such as showing real-life workplace situations or using ICT for assessments. However, one standout item, related to recording classes using ICT, achieved 100% agreement and a mean score of 5.00, highlighting its strong relevance in modern pedagogical practices. Overall, all items were retained, demonstrating consistency in expert agreement.

4.3.1.3 Lesson Preparation

In Lesson Preparation, the items received slightly more varied responses, with agreement rates ranging from 70% to 90%. The mean scores ranged from 3.50 to 4.50, but each item still achieved a CVI of 1.00, signifying that they met the minimum threshold for relevance. Nevertheless, items concerning designing videos and images for STEM teaching received lower agreement rates (70%) and mean scores (3.50), indicating that these areas are lless essential or less developed in current teaching practices compared to other items.

4.3.1.4 Peer Collaboration

The items in ‘Peer Collaboration’ focused on educators working with peers to develop teaching materials and solve technical problems. Most items achieved a 90% agreement rate, with mean scores of 4.50 and a CVI of 1.00, emphasizing the importance of collaboration among TVETMARA educators. The strong consensus suggests that peer collaboration is considered a critical component of ICT integration in STEM education.

4.3.1.5 Organisation Support

In Organisation Support, the highest consistency was seen in this domain, where all items achieved 90% agreement, a mean score of 4.50, and a CVI of 1.00. These items

reflect the extent to which the organization supports educators by providing ICT tools, training, and resources tailored to course syllabus, technical field, and industry needs. The uniformity in responses indicates a strong agreement among the experts regarding the importance of organizational support for effective ICT integration.

The results from the expert panel review highlight strong agreement on the necessity and sufficiency of the items in the STEM ICT Teaching Inventory. With most items receiving high agreement percentages and CVI scores of 1.00, it is evident that the items within the SITI are well-aligned with the key constructs of ICT integration in STEM teaching among TVETMARA educators. The overall consensus underscores the relevance of these items for evaluating and improving teaching practices in the context of modern educational technologies.

Table 4.13: Interpretation of Items Based on Content Validity Index (CVI) for ICT Selection

	Item	Percentage (%)	Mean	CVI	Interpretation
1	I select ICT which aligns with my learning outcomes.	90.00	4.50	1.00	Remained
2	I select ICT which aligns with my teaching methods in Theory class.	90.00	4.50	1.00	Remained
3	I select ICT which aligns with my teaching methods in Practical class.	90.00	4.50	1.00	Remained
4	I select ICT which aligns with my teaching method (demonstration).	90.00	4.50	1.00	Remained

Table 4.13 Continued

5	I select ICT which aligns with my teaching method for hands-on.	90.00	4.50	1.00	Remained
6	I select ICT which aligns with my teaching method	90.00	4.50	1.00	Remained
7	I select ICT which aligns with my teaching method (project-based learning).	90.00	4.50	1.00	Remained
8	I select ICT which aligns with my teaching method (inquiry-based learning).	90.00	4.50	1.00	Remained
9	I select ICT which aligns with my teaching method (group learning).	90.00	4.50	1.00	Remained
10	I select ICT which aligns with my teaching method (case study).	90.00	4.50	1.00	Remained

Table 4.14: Interpretation of Items Based on Content Validity Index (CVI) for Pedagogical Practices

	Item	**Percentage (%)**	**Mean**	**CVI**	**Interpretation**
1	I use videos from internet to show real life/ workplace situations.	90.00	4.50	1.00	Remained
2	I use images from internet to show real life/workplace situations.	90.00	4.50	1.00	Remained

Continued

3	I use computer aided design to show real life/workplace situations.	80.00	4.00	1.00	Remained
4	I use ICT to record my classes (theory/practical).	100.00	5.00	1.00	Remained
5	I use ICT to record my students' attendance.	80.00	4.00	1.00	Remained
6	I use ICT for submission of my students' work.	90.00	4.50	1.00	Remained
7	I use ICT to differentiate my students' learning styles.	80.00	4.00	1.00	Remained
8	I use ICT based task for my students' assessment.	90.00	4.50	1.00	Remained
9	I use ICT to conduct my students' evaluation. (eg Microsoft/Google form/quizizz/liveworksheet).	90.00	4.50	1.00	Remained

Table 4.15: Interpretation of Items Based on Content Validity Index (CVI) for Lesson Preparation

	Item	**Percentage (%)**	**Mean**	**CVI**	**Interpretation**
1	I design my daily lesson plan that integrates ICT in STEM teaching.	90.00	4.50	1.00	Remained
2	I develop my own video for STEM teaching.	70.00	3.50	1.00	Remained
3	I design my PowerPoint slides based on my learning outcomes in STEM teaching.	90.00	4.50	1.00	Remained
4	I design images using ICT to demonstrate complex ideas in STEM teaching.	70.00	3.50	1.00	Remained

Table 4.15 Continued

5	I design images using ICT to visualize learning contents that difficult to observe explicitly in STEM teaching.	80.00	4.00	1.00	Remained
6	I install computer design software before STEM teaching.	80.00	4.00	1.00	Remained
7	I upload my teaching digital materials before STEM teaching.	80.00	4.00	1.00	Remained
8	I share website link with students before STEM teaching.	80.00	4.00	1.00	Remained

Table 4.16: Interpretation of Items Based on Content Validity Index (CVI) for Lesson Preparation

	Item	Percentage (%)	Mean	CVI	Interpretation
1	I design my daily lesson plan that integrates ICT in STEM teaching.	90.00	4.50	1.00	Remained
2	I develop my own video for STEM teaching.	70.00	3.50	1.00	Remained
3	I design my PowerPoint slides based on my learning outcomes in STEM teaching.	90.00	4.50	1.00	Remained
4	I design images using ICT to demonstrate complex ideas in STEM teaching.	70.00	3.50	1.00	Remained
5	I design images using ICT to visualize learning contents that difficult to observe explicitly in STEM teaching.	80.00	4.00	1.00	Remained

Table 4.16 Continued

6	I install computer design software before STEM teaching.	80.00	4.00	1.00	Remained
7	I upload my teaching digital materials before STEM teaching.	80.00	4.00	1.00	Remained
8	I share website link with students before STEM teaching.	80.00	4.00	1.00	Remained

Table 4.17: Interpretation of Items Based on Content Validity Index (CVI) for Peer Collaboraton

	Item	Percentage (%)	Mean	CVI	Interpretation
1	I develop videos for hands-on class with MARA TVET peers.	80.00	4.00	1.00	Remained
2	I develop PowerPoint slides for STEM teaching with MARA TVET peers.	80.00	4.00	1.00	Remained
3	I develop pictures and images for STEM teaching with MARA TVET peers.	90.00	4.50	1.00	Remained
4	I share STEM teaching digital materials with MARA TVET peers.	90.00	4.50	1.00	Remained
5	I share STEM teaching digital assessment materials with MARA TVET peers.	90.00	4.50	1.00	Remained
6	I collaborate with students' apprentice to assist students to solve technical problem (eg installing software, wifi).	90.00	4.50	1.00	Remained

Table 4.17 Continued

7	I collaborate with peers from technical group to assist with technical problems (eg installing software, wifi).	90.00	4.50	1.00	Remained

Table 4.18: Interpretation of Items Based on Content Validity Index (CVI) for Organisation Support

	Item	Percentage (%)	Mean	CVI	Interpretation
1	My organization provides ICT based on MARA TVET course syllabus needs.	90.00	4.50	1.00	Remained
2	My organization provides ICT based on technical field needs.	90.00	4.50	1.00	Remained
3	My organization provides ICT which aligns with industry needs.	90.00	4.50	1.00	Remained
4	My organization provides sufficient lab facilities.	90.00	4.50	1.00	Remained
5	My organization provides digital teaching materials (eg e-module)	90.00	4.50	1.00	Remained
6	My organization provides ICT training to enhance ICT knowledge.	90.00	4.50	1.00	Remained
7	My organization provides ICT training to enhance content knowledge.	90.00	4.50	1.00	Remained
8	My organization provides ICT training to enhance pedagogical knowledge.	90.00	4.50	1.00	Remained

4.3.2 Pre-testing

Pre-testing was conducted in the early stages of SITI development, after the initial items' generation (Second phase). The purpose of conducting pre-testing in SITI development was to assess and refine the measurement instrument before using it in the pilot study and field study data collection. The online STEM ICT Teaching Inventory pre-testing was conducted using a convenient sample of thirteen TVETMARA educators (Table 4.19).

The researcher posted the link of the online SITI instrument through instant messaging (WhatsApp) and email. Firstly, she requested the participants to read and respond to the items in the SITI. After completing the online SITI, the researcher set the interview mode for the participants either they would like the interview session via instant messaging (WhatsApp) or face-to-face. Eleven participants requested for instant messaging mode while two via face-to-face.

Table 4.19: Demographic Information of Pre-Testing Participants

Demographic Information	n	Percentage (%)
Gender		
Male	7	53.8
Female	6	46.2
Age		
Less than 30 years	0	0
30 – 40	4	30.8
41 – 51	8	61.5
More than 51	1	7.7

Table 4.19 Continued

Numbers of years teaching		
Less than 5 years	0	0
5 – 10	1	7.7
11- 15	5	38.5
16- 20	4	30.8
More than 20 years	3	23.0
Education level		
Diploma	4	30.8
Degree	3	23.1
Masters	5	38.5
PhD	1	7.6

In this study, pre-testing serves the following purposes:

1. Evaluate Clarity and Comprehensibility: Pre-testing allowed the researcher to assess the clarity and comprehensibility of STEM ICT Teaching Inventory items. After the participants in pre-testing completed the online SITI, the researcher interviewed the participants via WhatsApp and face-to-face. The researcher asked the following questions:

    i) 'Are they terms in the items that are not cleared for example, 'computer aided design', 'inquiry based learning', 'case study'.

    ii) Is the online instructions clear?

    iii) Do each section in SITI clearly defined?

    iv) Are they any other sections that are not cleared or confusing)?

Since the instrument consists of terms from SPMa and commonly used by TVETMARA educators in the teaching and learning process, majority of the participants reported SITI items were clear and concise and length of SITI was appropriate. Furthermore, the format of SITI was easy to follow.

2. Assess Relevance and Appropriateness: Pre-testing helped the researcher evaluate the relevance and appropriateness of the content in the STEM ICT Teaching Inventory. The researcher asked the participants' feedback if the items in SITI adequately covered elements of best teaching practices in STEM teaching with the inclusion of ICT. This assessment ensured that SITI aligned with the emphasis on ICT in the teaching and learning process of TVETMARA. Feedback from the participants also indicated that items in SITI captured the standard practices (SPMa) in TVETMARA teaching.

3. Identify Response Difficulties: Pre-testing provided an opportunity to identify any difficulties participants encounter while responding to SITI. It included issues like ambiguous response options, unclear instructions, or formatting problems. By identifying and addressing these issues during pre-testing, the researcher could enhance the overall STEM ICT Teaching Inventory quality and minimize potential response errors. Though nine participants found no difficulties while answering SITI, one participant remarked on the inconsistent terms MARA TVET and TVETMARA. She also suggested distributing SITI consisting of Malay and English. It helped intended participants to choose which language they preferable to answer.

4. Refine and Improve the Instrument: The feedback obtained during pre-testing served as valuable input for refining and improving SITI. The researcher used

the participants' suggestions, comments, and concerns to revise the items' wording such as MARATVET to TVETMARA. The researcher also prepared online SITI in Bahasa Malaysia and English language.

5. Enhance Participant Experience: Pre-testing allowed the researcher to gauge participants' experience in completing SITI, which was a self-report survey and distributed online. By gathering feedback on the length, complexity, and overall user-friendliness, the researcher adjusted by adding video instructions to enhance the participant experience. This led to improved response rates, reduced participant burden, and increased engagement in the SITI validation study.

Table 4.20: Response Rate Participant

Participant	Response (minutes)
P1	12
P2	10
P3	36
P4	23
P5	9
P6	9
P7	7
P8	7
P9	13
P10	16
P11	5
P12	36
P13	4

The data presented in Table 4.20 provides valuable insights when used as pre-test results for evaluating the effectiveness SITI to assess ICT integration practices in STEM teaching. The variation in response times, ranging from as short as 4 minutes (P13) to as long as 36 minutes (P3 and P12), that suggested a diverse level of engagement and familiarity with ICT tools among the participants. Educators who took longer to complete the assessment might have reflected more deeply on their integration practices or may need additional support in understanding the items in SITI. Shorter response times could indicate either a higher level of proficiency with ICT or a more cursory understanding of the integration process. Overall, the data highlights the need for the researcher to provide clearer explanations on the sections and items SITI instruments before distributing in pilot study and field study.

4.4 Quantitative Results (Phase 3)

The purpose of this study was to address the research question:

1) To what extent is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integration practices in STEM teaching?

2) Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?

4.4.1 Exploratory Factor Analysis

Exploratory factor analysis (EFA) is utilised in instrument development to identify latent constructs for theory building or to create measurement instruments (Taherdoost, 2016; Watkins, 2018). Demonstrating a resulting measurement instrument that reflects a meaningful underlying construct is useful. The multivariate statistical approach known as

EFA has emerged as a crucial instrument in the field of STEM Education research and assessment, playing a significant role in both the development and validation processes (Maric et al., 2023; Wahono & Chang, 2019). This study used EFA to determine the underlying structure and refine the STEM ICT Teaching Inventory.

Five stages were carefully considered before doing exploratory factor analysis (EFA). The first phase assessed the suitability of using exploratory factor analysis (EFA) as the statistical technique to fulfil the research objectives effectively. Furthermore, it is essential to carefully determine the variables and sample size for the research. Third, the extraction procedure should be chosen and then the method to decide the number of factors to retain. The appropriate rotation technique should be used to get a conclusive and comprehensible answer.

In this study, the EFA test was conducted as part of the analysis to determine construct validation of the STEM ICT Inventory (Taherdoost et al., 2022). Based on qualitative findings in Phase One, five factors were proposed to represent the measure of ICT integration practices in STEM teaching of TVETMARA educators: ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practices and Lesson Preparation with a total of 42 items. Since communalities were greater than 0.6 and factors were strongly determined by three or more items (de Winter et al., 2009; Fabrigar et al., 1999; Maccallum et al., 1999), a sample size of 162 respondents was reasonable and enough for the EFA test of the STEM ICT Teaching Inventory. Regarding item-to-response, ratios from 1:4 to 1:10 are recommended for each set of scales to be factor analysed (DeVellis, 2016). Since an online survey was used to collect data, where every question had to be answered to submit the completed survey successfully, there was no missing value problem.

EFA was undertaken to examine the dimensional structure of the STEM ICT Teaching Inventory by grouping items under the same dimensions and identifying other underlying dimensions. The EFA study used Principal Axis Factoring and Promax with Kaiser Normalization rotation using IBM SPSS 22. Principal Axis Factoring is a proposed extraction method for instruments with a theoretical background. Therefore, this study used principal axis factoring as its extraction method since the STEM ICT Teaching Inventory was developed based on TPACK's theoretical background. At the same time, Promax rotation allows the items in the instrument to be correlated. The measured value of Kaiser-Meyer-Olkin (KMO) sample appropriateness was 0.904, which is suitable for factor analysis. The minimum factor loading was kept at 0.45 since the number of respondents was between 150 and 200 (Hair et al., 2014).

Initially, the factor solution yielded seven factors of the STEM (ICT) Teaching Inventory, which accounted for 66.792% of the variation in the data. Three criteria were used for factor structure evaluation: failure to load, items loading and cross-loading. The initial factor structure showed that two items did not load significantly under Pedagogical Practices, and four items under Lesson Preparation failed to load substantially.

Table 4.21: Initial Removed Factors and Items that Did Not Load Significantly

Factor	**Item**
Pedagogical Practice	I use computer aided design to show real life/workplace situations
Pedagogical Practice	I use ICT to record my students' attendance
Lesson Preparation	I design my daily lesson plan that integrates ICT in STEM teaching
Lesson Preparation	I design my PowerPoint slides based on my learning outcomes in STEM teaching
Lesson Preparation	I install computer design software before STEM teaching
Lesson Preparation	I share website link with students before STEM teaching

These items were removed, and factor analysis was re-run. The factor solution yielded six factors of the STEM (ICT) Teaching Inventory, which accounted for 68.163% of the variation in the data. Substantially, two items under Lesson preparation failed to load and were removed from further analysis.

Table 4.22: Second Removed Items that Did Not Load Significantly

Factor	Item
Lesson Preparation	I develop my own video for STEM teaching
Lesson Preparation	I upload my teaching digital materials before STEM teaching

Removal of these items led to a five-factor solution with 32 items. In the final analysis, two items of Lesson Preparation did not load significantly and no items were contained under Lesson Preparation.

Table 4.23: Third Removed Items that Did Not Load Significantly

Factor	Item
Lesson Preparation	I design images using ICT to demonstrate complex ideas in STEM teaching
Lesson Preparation	I design images using ICT to visualize learning contents that difficult to observe explicitly in STEM teaching

In the final factor analysis, Table 4.25 showed the Kaiser-Mayer-Olkin MSA was 0.905. In Table 4.27 showed a five-factor solution with 68.049% variance explained by the items. Using Bartlett's test, the overall correlation matrix was significant.

Table 4.24: The Factors Identified in EFA

Factor	No. of Items	Description
Factor 1: ICT selection (ICS)	10 items	This factor consists of items that describe the ICT selection of TVET MARA educators based on TVET MARA curriculum goals and teaching methods.
Factor 2: Organisation Support (OS)	8 items	This factor consists of items that highlight the support given by the organization in providing teaching and learning facilities of ICT that are conducive and trainings that enhance pedagogy in integrating ICT.
Factor 3: Peer Collaboration (PC)	7 items	This factor refers to items that display the collaboration with teaching group (TVET MARA peers) and technical group (students and IT officers. The collaboration with peers of TVET MARA are develop digital teaching materials and receiving troubleshooting assistance from technical group.
Factor 4: Pedagogical Practices (PP)	5 items	This factor consists of items that measure the used of ICT in class management to support learning occurs effectively,
Factor 5: STEM teaching (ST)	2 items	This factor consists of items that describe ICT usage in pedagogical practices of STEM teaching.

Table 4.25 shows EFA results. Using EFA analysis, this study found that 32 STEM (ICT) Teaching Inventory items produced five factors: ICT selection, Organisation Support, Peer Collaboration, ICT in Pedagogical Practices and STEM teaching. The first factor, ICT Selection, consists of 10 items with a factor loading range of 0.578 to 0.893. The second factor, Organisation Support, pertains to support received from TVETMARA as an organisation comprising eight items with a factor loading range from 0.745 to 0.897. The third factor, Peer Collaboration, includes seven items that capture collaboration activities among TVETMARA peers. The factor loading ranges from 0.526 to 0.932. The fourth factor, ICT in Pedagogy, consists of 5 items with a factor loading range from 0.475

to 0.843. The fifth factor of STEM teaching that represents the criteria of STEM teaching as a teaching strategy in TVETMARA consists of 2 items with factor loading ranging from 0.752 to 0.868. Though it is not favorable to have only two items to measure STEM teaching construct, but it is a common situation to remove poor quality items and result with two items ((Domínguez Lara et al., 2016; Eisinga et al., 2013). The two items in STEM teaching represent the used of digital technologies to illustrate workplace problem.

Interestingly, in the analysis, the proposed construct Lesson Preparation was absent from the final factors identified through factor analysis. The items in this construct represented preparation activities of TVETMARA educators in developing digital teaching and learning materials based on course structures, students' readiness with the ICT teaching method used, and ICT facilities provided by the institution. These items were overlapped in content with other items in the item pool and were removed due to low factor loadings. Moreover, there is a medium-strength correlation between the first factor (ICT Selection) and the third factor (Peer Collaboration), with an inter-factor correlation of r =0.529 and r = 0.568, respectively (Asuero et al., 2006). This correlation indicates that items in the factor Lesson Preparation are related to items in ICT selection and factor Peer Collaboration. For example, item LP3, ' I design my PowerPoint slides based on my learning outcomes in STEM teaching,' cross loading in factor 1 (r=0.485) and factor 3(r= 0.592). This conclusion is confirmed by prior research that highlighted the need of comprehensive lesson preparation, which necessitates taking into account vocational elements such as curriculum features, student characteristics, and the availability of learning support tools. (Kamal et al., 2023; Nurtanto et al., 2020; Purwinda Anggrella et al., 2023).

Table 4.25: EFA Analysis

	Factor					Communalities
	ICT Selection	Organisation Support	Peer Collaboration	ICT in Pedagogy	STEM teaching	
ICT Selection 1	.675					.660
ICT Selection 2	.623					.648
ICT Selection 3	.863					.618
ICT Selection 4	.846					.701
ICT Selection 5	.875					.619
ICT Selection 6	.893					.734
ICT Selection 7	.812					.724
ICT Selection 8	.762					.661
ICT Selection 9	.653					.727
ICT Selection 10	.578					.536
Pedagogy1					.752	.742
Pedagogy2					.868	.865
Pedagogy4				.475		.400
Pedagogy6				.816		.685
Pedagogy7				.659		.632
Pedagogy8				.843		.734
Pedagogy9				.756		.642
Peer1			.526			.466
Peer2			.864			.709
Peer3			.932			.759
Peer4			.883			.791
Peer5			.857			.774
Peer6			.722			.625
Peer7			.639			.538
Organisation1		.874				.728
Organisation2		.873				.762
Organisation3		.779				.686
Organisation4		.793				.644
Organisation5		.745				.674
Organisation6		.882				.775
Organsation7		.897				.796
Organisation8		.837				.719

Nevertheless, the study highlights an inconsistency between factors in EFA and qualitative findings. Qualitative findings proposed five themes: ICT selection (ICS),

Organisation Support(OS), Peer Collaboration(PC), Pedagogical Practices(PP) and Lesson preparations(LP). The inconsistency is due to the theme Lesson Preparation, which was proposed as a separate factor, is found to be significantly related to both ICT selection and Peer Collaboration. This suggests that the use of Information and Communication Technology (ICT) tools and Peer Collaboration may account for some aspects pertaining to lesson preparation. Therefore, items in factor ICT Selection and factor Peer Collaboration are also represented by items in lesson preparation.

Table 4.26: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.905
Bartlett's Test of Sphericity	Approx. Chi-Square	4867.364
	df	496
	Sig.	.000

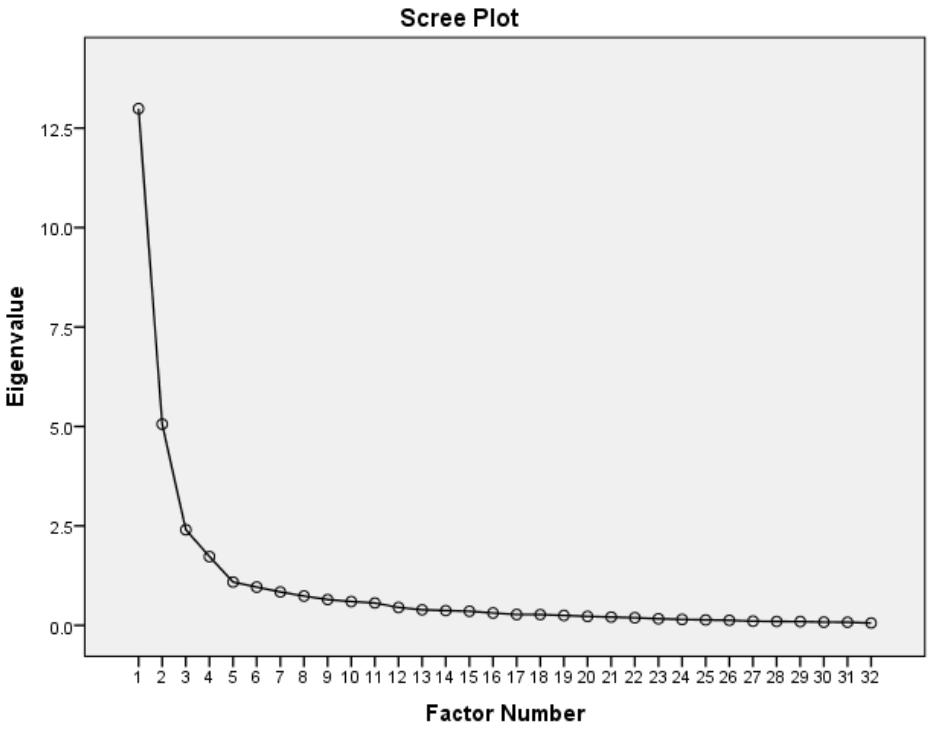


Figure 4.7: Scree Plot

Table 4.27: Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	12.988	40.586	40.586	12.671	39.596	39.596	10.063
2	5.058	15.808	56.394	4.764	14.889	54.485	8.075
3	2.403	7.508	63.902	2.114	6.607	61.092	8.677
4	1.728	5.400	69.302	1.386	4.332	65.424	7.747
5	1.088	3.399	72.700	.840	2.625	68.049	5.066
6	.962	3.007	75.707				
7	.840	2.624	78.331				
8	.736	2.301	80.632				
9	.648	2.025	82.657				
10	.599	1.871	84.528				
11	.561	1.754	86.282				
12	.450	1.405	87.686				
13	.391	1.223	88.909				
14	.370	1.156	90.066				
15	.355	1.108	91.174				
16	.311	.973	92.147				
17	.273	.853	93.000				
18	.271	.846	93.846				
19	.248	.775	94.621				
20	.225	.703	95.324				
21	.209	.653	95.977				
22	.191	.597	96.574				
23	.166	.520	97.094				
24	.148	.462	97.556				
25	.136	.425	97.981				
26	.128	.400	98.381				
27	.105	.327	98.708				
28	.099	.311	99.019				
29	.096	.301	99.319				
30	.081	.253	99.572				
31	.078	.242	99.815				
32	.059	.185	100.000				

Extraction Method: Principal

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance

4.4.2 Reliability Analysis of EFA

In Table 4.28, for field study 1 (EFA), an internal consistency reliability analysis (N=162) was conducted on each factor on the STEM ICT Teaching Inventory instrument. The Pedagogical Practices factor had the lowest reliability at and for the nine items. Second, the coefficient alpha and omega for the eight items of the Lesson Preparation factor were 0.900 and 0.902, respectively. Third, the seven-item Peer Collaboration factor coefficient alpha and omega were 0.920 and 0.924, respectively. Fourth, the ten items of the ICT Selection factor had coefficient alpha and omega of 0.943 and 0.946. Fifth, the Organisation Support factor had the highest reliability at and for the eight items. Overall, the instrument's reliability analysis was high, indicating adequate internal consistency reliability.

Table 4.28: Reliability Analysis of Factor (EFA)

Factor	Cronbach Alpha	McDonald Omega
ICT Selection	0.943	0.946
Pedagogical Practices	0.885	0.887
STEM Teaching	0.900	0.902
Peer Collaboration	0.920	0.924
Organisation Support	0.951	0.952

4.4.3 Confirmatory Factor Analaysis

A second data set with 265 observations (n= 265) was evaluated using IBM SPSS Amos 26 using Confirmatory Factor Analysis (CFA). The CFA method is used to verify the STEM ICT Teaching Inventory's factor structure, dimensions, and validity.

In CFA, the test shows how well the hypothesized model from EFA explains the observed patterns. For confirmatory factor analysis, factor loadings were assessed for each item. The item would be removed if factor loading was less than 0.50(<.50). Table 4.21 shows the results obtained from the CFA analysis with its recommended value from the literature. It was determined that all goodness-of-fit metrics (CMIN/df, GFI, CFI, TLI, SRMR, and RMSEA) were within the ranges recommended by Ullman (2001), Hu and Bentler (1998), and Bentler (1990) ((Bentler, 1990; L.-T. Hu & Bentler, 1998; Ullman, 2006).

The five-factor model (ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practice and STEM teaching) yields a good fit. Various fit statistics and cut-off values were computed in this study. For instance, the Tucker-Lewis Index (TLI) and comparative fit index (CFI) were assessed, with values equal to or greater than 0.90 considered as indicative of adequate fit, while values equal to or greater than 0.95 were indicative of close model fit. Furthermore, the standardized root mean square residual was calculated with values of 0.80 or less indicating a satisfactory fit and root mean square error of approximation (RMSEA) was calculated with values of 0.05 or less indicating an adequate fit.

Originally, the five-factor model revealed a marginal fit to the data (CFI = 0.865, TLI = 0.853 and RMSEA = 0.095). Several data-model fit statistics and cut-ff values were calculated: Tucker-Lewis Index (TLI) and comparative fit index (CFI) $\geq$ 0.90 = adequate and $\geq$ 0.95 = close model fit; standardized root mean square residual (SRMR) and root mean square residual (SRMR) and root mean square error of approximation (RMSEA) $\leq$ 0.80 = adequate and $\leq$ 0.05 = close model fit.

Table 4.29: Results for Model Fit

Fit Indices	Recommended Value	Source(s)	Obtained Value
P	Insignificant	Bagozzi and Yi (1998)	0.000
CMIN/df	3-5	Less than 2 (Ullman, 2001) to 5 (Schumacker and Lomax, 2004)	2.131
GFI	>.90	Hair et al. (2010)	0.823
CF1	>.90	Bentler (1990)	0.938
TLI	>.90	Bentler (1990)	0.930
SRMR	<.80	Hu and Bentler (1998)	0.0426
RMSEA	<.80	Hu and Bentler (1998)	0.072

From the Round 1 result, there is evidence that items are not adequately measuring STEM (ICT) Teaching construct. Decisions to retain the items are based on several criteria. To improve the model fit, firstly check on the outer loadings where loadings with less than 0.50 are considered to be removed. Looking into loadings from the AMOS output, all the items had loadings greater than 0.50, with the lowest loading PP4 (r= 0.657). Hence, none of the items were removed based on this criterion. Secondly, when the modification indices were high between two items or between two error terms within the same factor, the model was evaluated whether to remove one item or covary them (error terms). Modification indices display the model's covariance paths and the chi-square's expected parameter change. After modification of indices , ten error terms were covaried in three rounds, and the model reached the criteria for the goodness-of-fit indices. The resulting model retains five factors and 32 items. The final model results in CFI = 0.938, TLI = 0.930, SRMR = 0.0426 and RMSEA = 0.072.

Table 4.30: Confirmatory Factor Analysis Process for The Model Fit STEM ICT Teaching Inventory

Round	χ^2	PCMIN/DF	TLI	GFI	CFI/AGFI	RMSEA	Item deletion or covariance
0	χ^2=1542.974 Df = 454 P = .000	3.399	.0.853	0.721	0.865/0.675	0.095	
1	χ^2=1243.966 Df = 451 P = .000	2.758	D0.892	0.779	0.902/0.741	0.082	Covary e12 and e13 (0S) due to modification index (111.932) Covary e17 and e18 (0S) due to modification index (88.429) Covary e7 and e8 (ICS) due to modification index (79.350)
2	χ^2=1068.251 Df = 448 P = .000	2.384	D0.915	0.807	0.923/0.789	0.065	Covary e9 and e10 (ICS) due to modification index (69.834) Covary e23 and e24 (PC) due to modification index (40.979) Covary e19 and e20 (PC) due to modification index (49.948)

Table 4.30 Continued

3	χ^2=946.340 Df = 444 P = .000	2.131	D0.930	0.823	0.938/0.772	0.072 SRMR = 0.0426	Covary e16 and e17 (0S) due to modification index (26.869) Covary e11 and e12 (OS) due to modification index (29.530) Covary e6 and e8 (ICS) due to modification index (25.417) Covary e1 and e2 (ICS) due to modification index (29.967)

Table 4.30 shows the CFA process of SITI. The confirmatory Factor Analysis (CFA) process for the STEM ICT Teaching Inventory involved a three series of iterative steps to improve the model fit through covariance adjustments based on modification indices. Initially, in Round 0, the model showed a chi-square value (χ^2) of 1542.974 with 454 degrees of freedom, indicating a poor fit, as reflected in indices such as the Tucker-Lewis Index (TLI) of 0.853, Comparative Fit Index (CFI) of 0.865, and Root Mean Square Error of Approximation (RMSEA) of 0.095. No adjustments were made during this initial step.

In Round 1, to improve the fit, specific covariances were added between error terms with high modification indices, including e12 and e13, e17 and e18, and e7 and e8. Error e12 and e13 are from item 2 and item 3 of construct Organisational Support. The basis for performing modification indices are similar content of item 2 and item 3, and e17 and e18 from item 7 and item 8 due to similar wordings. Modification indices by allowing errors of e12 and e13, e17 and e18, and e7 and e8 correlate due to similar content and wordings can help to improve SITI model (Goretzko et al., 2024), These adjustments led to a better model fit, with the chi-square value decreasing to 1243.966, TLI improving to 0.892, CFI to 0.902, and RMSEA reducing to 0.082. Round 2 continued this process by adding covariances between additional pairs of error terms (e9 and e10, e23 and e24, and e19 and e20) based on their modification indices. Moreover, allowing these similar wording items covaried, the model can better capture the items relationship. Hence, resulting in further improvements: the chi-square value dropped to 1068.251, TLI increased to 0.915, CFI to 0.923, and RMSEA to 0.065. With the decrease value in the chi-square indicates the 5 factor model's prediction is aligned with the actual measured item (Prudon, 2015).

The final round, Round 3, made additional covariance adjustments among error terms, specifically e16 and e17, e11 and e12, e6 and e8, and e1 and e2. These changes yielded the best model fit, with the chi-square value reducing to 946.340, TLI reaching 0.930, CFI at 0.938, and RMSEA at 0.072, with an additional standardized root mean square residual (SRMR) of 0.0426 indicating an acceptable fit. This iterative approach of refining the model by addressing high modification indices through error term covariances effectively enhanced the overall model fit, making the inventory more robust and reliable for assessing STEM ICT teaching.

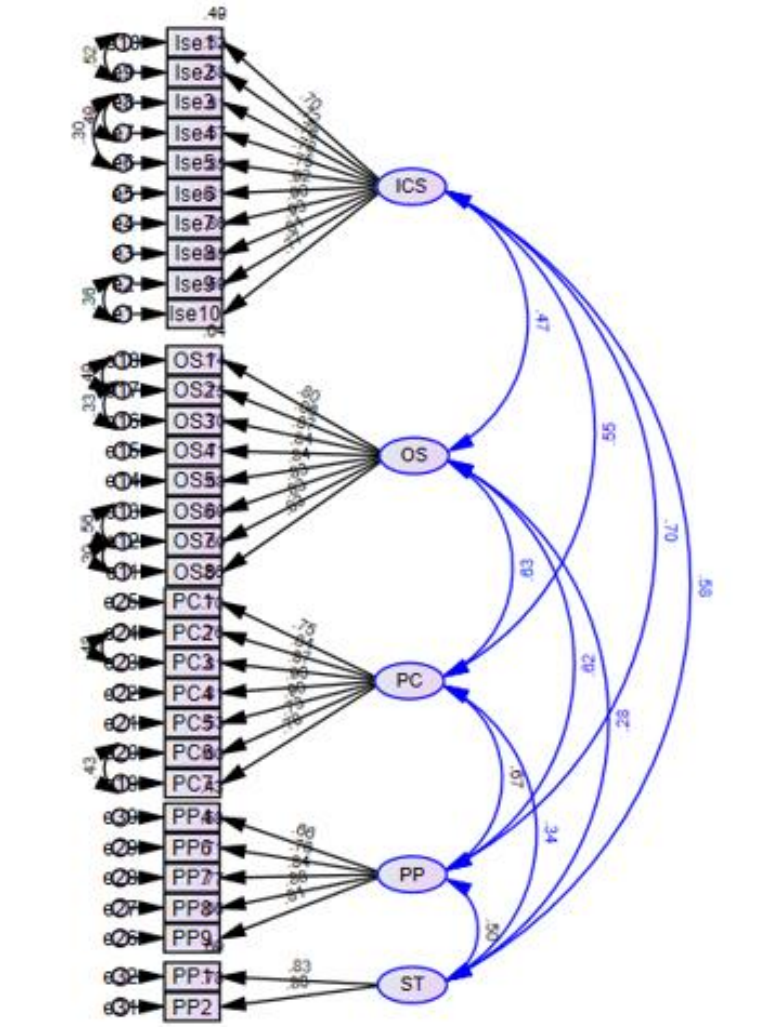


Figure 4.8: The Finalized Model with Standardized Coefficients

4.4.4 Construct Validation

In this study, the construct validation was established using convergent validity and discriminant validity. The convergent validity of scale items was estimated using the Average Variance extracted (Fornell & Larcker, 1981). Based on Table 4.23, the average variance-extracted value was above the threshold value of 0.50 for construct ICT Selection with factor loadings of all items greater than 0.7 except for Ise1(r =0.698). However, with alpha and CR values above 0.7, the construct ICT Selection was valid. For construct Organisation Support, the AVE was 0.701 and factor loadings ranged from 0.798 to 0.867 (Fornell & Larcker, 1981). The average variance-extracted values were also above the threshold value of 0.50 for construct Peer Collaboration, Pedagogical Practices and STEM Teaching with AVEPC = 0.68, AVEPP = 0.894 and AVEST = 0.849, respectively. All the factor loadings of items in the three constructs were above 0.70 except for PP4 (r = 0.656) from construct Pedagogical Practices. Since alpha and CR value were above the threshold value of 0.70, Pedagogical Practices was a valid construct. Therefore, the five constructs and 32 items used for the present study have the required convergent validity.

Table 4.31: Factor Loadings of CFA

Items	Loadings	AVE
ICT Selection		0.652
Ise1	0.698	
Ise2	0.718	
Ise3	0.759	
Ise4	0.783	
Ise5	0.753	
Ise6	0.924	
Ise7	0.903	
Ise8	0.926	

Table 4.31 Continued

Ise9	0.805	
Ise10	0.768	
Organisation Support		0.701
OS1	0.798	
OS2	0.863	
OS3	0.867	
OS4	0.837	
OS5	0.841	
OS6	0.827	
OS7	0.832	
0S8	0.832	
Peer Collaboration		0.68
PC1	0.750	
PC2	0.835	
PC3	0.870	
PC4	0.897	
PC5	0.898	
PC6	0.729	
PC7	0.775	
Pedagogical Practices		0.894
PP4	0.656	
PP6	0.765	
PP7	0.843	
PP8	0.876	
PP9	0.810	
STEM Teaching		0.849
ST1	0.832	
ST2	0.885	

According to Fornell and Larcker (1981), discriminant validity is considered to be proven when the correlation between a specific construct and the other constructs being studied is less below the square root of the average variance extracted (AVE) for that construct. However, the Fornell and Larcker criterion has recently been criticized, and a new method to assess the discriminant validity, the HTMT ratio, is increasingly utilized. Table 4.24 to Table 4.25 establish discriminant validity using the Fornell and Larcker criterion and HTMT. When assessed using the HTMT ratio, all ratios were less than the required limit of .85 (Henseler et al., 2015). Hence, the discriminant validity was established.

Table 4.32: Fornell and Larcker for Discriminant Validity

	ICS	**OS**	**PC**	**PP**	**ST**
ICS	***0.807***	0.47	0.552	0.701	0.576
OS	0.470	***0.837***	0.633	0.622	0.284
PC	0.552	0.633	***0.824***	0.667	0.335
PP	0.701	0.622	0.667	***0.793***	0.498
ST	0.576	0.284	0.335	0.498	***0.859***

Table 4.33: HTMT Ratio for Discriminant Validity

	ICS	**OS**	**PC**	**PP**	**ST**
ICS					
OS	0.458				
PC	0.54	0.878			
PP	0.693	0.615	0.661		
ST	0.57	0.281	0.332	0.5	

4.4.5 Realibility Analysis of CFA

The reliability of the study's constructs is measured by their internal consistency. The degree of correlation between items is considered to be internal consistency reliability. It shows that multiple items measure the same construct and intercorrelate with one another. Low inter-item correlations indicate that some items are drawn from inappropriate domains that cause unreliability.

In the reliability analysis to examine the corrected item-to-total correlations and irrelevant factors with loading values lower than 0.45 and associated with more than one factor. For the field study 2, an internal consistency reliability analysis (N=265) was conducted on each factor on the STEM ICT Teaching Inventory instrument using Cronbach's Alpha, McDonald Omega and Composite Reliability.

In the Cornbach's Alpha analysis, a construct is reliable if the Alpha (α) value is greater than 0.70 (Nunnally & Bernstein, 1994).n Table 4.34, using Cronbach's Alpha to test construct reliability, the results revealed that the ICT Selection with ten items ($\alpha = 0.947$), Organisation Support with eight items ($\alpha = 0.951$) and Peer Collaboration with seven items ($\alpha = 0.940$) were found reliable. Similarly, to construct Pedagogical Practices with five items ($\alpha = 0.890$) and STEM Teaching with two items ($\alpha = 0.847$) was also found to be reliable.

Table 4.34: Reliability Statistics STEM (ICT) Teaching Inventory

Construct	No. of Items	Cronbach's Alpha (α)
ICT Selection	10	0.947
Organisation Support	8	0.951
Peer Collaboration	7	0.940
Pedagogical Practice	5	0.890
STEM Teaching	2	0.847

Table 4.35 shows the reliability analysis using McDonald's Omega, an alternative reliability analysis for items with normal distribution (Trizano-Hermosilla & Alvarado, 2016). The results revealed that the ICT Selection with ten items ($\omega = 0.952$), Organisation Support with eight items ($\omega = 0.952$) and Peer Collaboration with seven items ($\omega = 0.938$) were found reliable. The Pedagogical Practices factor with five items are reliable ($\omega = 0.893$) and STEM Teaching with two items ($\omega = 0.848$) had the lowest reliability. Overall, the instrument's reliability analysis using McDonald Omega was high, indicating adequate internal consistency reliability.

Table 4.35: Reliability Analysis of Factor (CFA)

Factor	No. of Items	McDonald Omega
ICT Selection	10	0.952
Organisation Support	8	0.952
Peer Collaboration	7	0.907
Pedagogical Practice	5	0.893
STEM Teaching	2	0.848

Table 4.36 shows the reliability analysis using Composite Reliability. The threshold value of Composite Reliability is above 0.70 (Hair, Matthews, Matthews, & Sarstedt, 2017). I Composite reliabilities ranged from 0.849 to 0.949 , above the 0.70 benchmark (Hair, Matthews, et al., 2017). The results revealed that the ICT Selection with ten items ($\rho_y = 0.949$), Organisation Support with eight items ($\rho_y = 0.911$) and Peer Collaboration with seven items ($\rho_y = 0.937$) were found reliable. The Pedagogical Practices factor with five items are reliable ($\rho_y = 0.894$) and STEM Teaching with two items ($\rho_y = 0.849$) had the lowest reliability. Overall, construct reliability was established for each construct in the study using Composite Reliability.

Table 4.36: Composite Reliability STEM (ICT) Teaching Inventory

Construct	No. of Items	Composite Reliability (CR)
ICT Selection	10	0.949
Organisation Support	8	0.911
Peer Collaboration	7	0.937
Pedagogical Practice	5	0.894
STEM Teaching	2	0.849

Table 4.37, outlines the key dimensions related to the integration of Information and Communication Technology (ICT) in the teaching practices of TVETMARA educators. The first dimension, 'ICT Selection', focuses on the selection of ICT tools that align with the goals of the TVETMARA curriculum and support appropriate teaching methods. The second dimension, 'Organisation Support', emphasizes the importance of organisational support in providing adequate teaching and learning facilities that are

conducive to effective ICT use, as well as offering necessary pedagogical training for educators.

Another important aspect is 'Peer Collaboration', which highlights the collaborative efforts among TVETMARA educators, students, and technical teams in the development of digital teaching materials and in troubleshooting ICT-related issues. The dimension of 'Pedagogical Practices' describes how ICT is utilized to enhance teaching approaches, particularly through the integration of various disciplines, and in classroom management to support effective learning outcomes. In the fifth dimension, 'STEM Teaching' underscores the role of ICT in delivering STEM education, specifically focusing on workplace applications in technical and engineering content, while integrating science, technology, and mathematics into the teaching process. The five dimensions provide a comprehensive framework for understanding the role of ICT in improving educational practices within the TVETMARA system.

Table 4.37: Final SITI Instrument Dimension Description

Quantitative Dimension from Themes	Dimension Description
ICT Selection	This dimension refers to ICT selection based on TVETMARA curriculum goals and teaching method.
Organisation Support	This dimension refers to support given by organization in providing teaching and learning facilities of ICT that are conducive and ICT pedagogical trainings.
Peer Collaboration	This dimension refers to collaboration with peers of MARA TVET Educators in developing digital teaching materials and collaboration with students and technical group to assist in troubleshooting.

Table 4.37 Continued

Pedagogical Practices	This dimension refers to ICT usage in pedagogical practices of STEM teaching that includes integration and cross disciplines as well as used of ICT in class management to support learning effectively.
STEM Teaching	This dimension refers to ICT usage in illustrating STEM teaching criteria : workplace application in technical and engineering content with the integration of science, technology and mathematics.

CHAPTER 5

DISCUSSIONS

5.1 Qualitative Discussions

TPACK framework guides the entire Qualitative phase. Five themes on the practices of ICT integration in STEM teaching among TVETMARA educators were generated from ten individual interviews, class observations and lesson plan analysis. The five themes are (1) ICT selection (2) Organisation support (3) Peer collaboration (4) Peer collaboration and (5) Lesson preparation.



Figure 5.1: Themes from Qualitative Findings

Table 5.1: Major Findings of Qualitative Study

Theme	Key Findings	Literature Connection
Criteria for ICT selection	Technology knowledge is dominant TPACK component	Fahadi & Khan, 2022; Mohammad Yunus & Mohamad, 2022; Mutanga et al., 2018).
	TCK guides the appropriate ICT tools that align with learning outcomes of technical courses.	Lee et al. (2020) Arifin et al. (2020; Subrahmanyam (2020); Khairul Anuar Abdul Rahman et al.(2022)
	TPK guides the appropriate ICT tools to be used with active learning strategies.	Lee et al. (2020); Khairul Anuar Abdul Rahman et al. (2022); Arifin et al. (2020)
Organisation Support	Support the enhancement of Technology knowledge (TK) by providing adequate ICT infrastructure	Ertmer & Ottenbreit-Leftwich, 2010; Ryan & Bagley, 2015). (Fu, 2013; Salehi & Salehi, 2012). (Ngeze, 2017).
	Role of educational leaders to provide contextual knowledge (XK) towards TVETMARA educators' awareness of ICT support.	Yilidrim, 2007; Divaharan et al , 2010, Tondeur et al. (2009)
	Professional development trainings provide ICT knowledge but lacking in pedagogical support.	Affouneh et al., 2020; Costa et al., 2022; D. Hu et al., 2021; Mumcu et al., 2022
Peer Collaboration	The collaboration in TVETMARA community develop TPK and TK through knowledge sharing and technical support	Hanimastura et al. 2016; Allan et al., 2010;Dong et al., 2019; Stevenson, 2004

Table 5.1 Continued

Pedagogical Practices	TPACK demonstrates the integration of ICT tools to enhance STEM teaching in the content of TVETMARA curriculum (technical and engineering)	Chan & Fitri Suraya, 2019; Hamidah & Fitri Suraya, 2022; Morales et al., 2022; Umutlu, 2022
	TPK supports the management of classroom activities, communication, and assessment processes, enhancing the pedagogical practices in the TVETMARA context.	Hamidah & Fitri Suraya, 2022; Istiningsih, 2022a; Junnaina & Hazri, 2014; Mutanga et al., 2018
Lesson Preparation	Lack in TPACK and XK to support thorough lesson planning that aligns both pedagogical strategies and ICT tools with TVETMARA curriculum goals and learning objectives.	Ghavifekr & Rosdy, 2015; Janssen & Lazonder, 2015; Rahmawati et al., 2021; Salehi & Salehi, 2012

The two goals of this study are to investigate how TVETMARA educators integrate ICT in their STEM teaching and to develop and validate an inventory to assess the components of incorporating ICT in STEM teaching in TVET. The first goal was achieved through a qualitative study, which included interviews, class observations and document analysis. The second aim was achieved by the implementation of a quantitative analysis, which effectively determined the validity and reliability of the inventory.

Significant findings of the qualitative study based on themes are discussed with the corresponding literature identified in this chapter and outlined in Table 5.1. The following highlights the significant findings organised by themes.

5.1.1 Theme 1: Criteria for ICT Selection

TVETMARA educators promote and facilitate the incorporation of ICT tools in the pedagogical approaches associated with STEM disciplines. The selection of these tools is predicated upon two criteria: the curricular requisites delineated in the TVEMARA syllabus and the implementation of active pedagogical strategies. By selecting tools such as AutoCAD software for engineering drawing instruction and simulators that correspond with industry standards, TVETMARA educators ensure that students acquire the requisite skills and knowledge pertinent to their designated technical fields. Moreover, the integration of visual aids, including videos and PowerPoint presentations, within active teaching methodologies significantly aids students in comprehending intricate concepts with enhanced efficacy. In addition, the utilization of online educational platforms such as Google Classroom, Microsoft Teams, and online chat functionalities provides students with convenient access to lessons and facilitates interactions with their educators. These resources not only serve to augment student

engagement but also cultivate a collaborative learning atmosphere in which students are encouraged to exchange ideas and seek support from both their peers and instructors.

Based on the qualitative findings of Theme 1, two distinct criteria guide TVETMARA educators in selecting the ICT tools they employ in their STEM teaching. Firstly, TVETMARA educators are inclined to choose ICT tools that fulfil their curriculum needs, which include engineering design and simulation. The second criterion is that TVETMARA educators tend to utilise ICT tools that support active teaching strategies such as demonstrations, group discussions, and hands-on and online teaching.

From the lenses of TPACK, both criteria suggest Technology Knowledge (TK) as its dominant component of TVETMARA educators' TPACK, in line with previous studies (Fahadi & Khan, 2022; Hamidah & Fitri Suraya, 2022; Mutanga et al., 2018). In this study, TK is essential knowledge in implementing STEM teaching as a pedagogical practice. It encompasses the ability to operate ICT tools such as knowledge of operating systems and computer hardware, standard software tools, for example, word processors, spreadsheets, browsers and email and ICT tools that support authentic learning experiences through simulators and virtual reality. ICT is a crucial and significant tool in improving STEM teaching and learning practice (Zubković et al., 2022). Therefore, teachers must have sufficient technology knowledge and skills to effectively teach and learn STEM (Goy et al., 2017; Türk et al., 2018). Technology knowledge is crucial in STEM teaching (Arifin et al., 2020) by combining it with scientific inquiry to create a robust learning environment (Sanders, 2009). Additionally, technology knowledge assists in making learning accessible to students through representations, analogies, examples, explanations, and demonstrations (Mishra & Koehler, 2006).

In the context of TVETMARA, its curriculum is designed to be industry-driven with advancements in ICT technology in line with the needs of IR 4.0. This includes areas such as IoT, simulation, video conferencing, social media and 3D modelling that are essential in producing a high-quality workforce (Hassan et al., 2021). The foundation of TVETMARA syllabi is based on ICT technology that integrates into technical courses through engineering design and simulations. As a result, TVETMARA educators are highly competent and comfortable when handling ICT technologies. This is consistent with previous research that suggests TVET lecturers are confident in their technology knowledge as a skill to teach their students (Hamidah & Fitri Suraya, 2022). A study by Mutanga et al. (2018) confirmed this finding that engineering educators are highly competent in their content and technology knowledge. This implies they are highly trained in their field and use technology in their teaching.

Moreover, it is crucial for TVETMARA educators to stay updated with the latest ICT technologies. This is because it is important to choose technologies that match the expectations of industries (Thang & Park, 2017). Hence, a previous study that confirmed this finding suggests introducing TK as a component that supports, improves and simplifies teaching and learning practice in TVET (Fahadi & Khan, 2022).

The rapid evolution of ICT tools presents a significant challenge to TVETMARA educators. The educators need to ensure that the ICT tools they utilise align with the learning outcomes in technical and engineering courses offered in TVETMARA centres. To address this challenge effectively, TVETMARA educators need to acquire sufficient technology content knowledge (TCK) to assist in making decisions when selecting appropriate ICT tools for their courses. TCK plays a crucial role in helping TVETMARA educators understand and become

proficient in using ICT tools to enhance the teaching and learning process in engineering and technical courses. During interviews with TVETMARA educators who taught Computer Aided Design (CAD), it was revealed that AutoCAD software benefits students. AutoCAD software enables students to design and analyse drawings for practical use. TVETMARA educators' TCK guides them to emphasise different aspects of CAD concepts based on their engineering and technical backgrounds. This strong foundation of TCK enables them to focus on imparting knowledge and skills by leveraging ICT tools.

A previous study confirmed that TVET teachers need to embrace technology and incorporate it into their teaching methods to ensure that their students achieve the intended learning outcomes (Lee et al., 2020). They must be able to harness the full potential of technology for the TVET teaching and learning process (Arifin et al., 2020). By using ICT tools such as simulations and videos, TVET educators can explain complex concepts of technical and engineering both visually and interactively (Khairul Anuar et al., 2022). Simulations, in particular, create opportunities for students to apply theory to practice in a realistic, safe and controlled environment. Hence, TCK of TVETMARA educators assist in developing engaging learning environments that facilitate understanding and application of complex technical concepts.

TVETMARA educators' Technology Pedagogical Knowledge (TPK) proficiency guides the successful integration of ICT tools into active teaching strategies. TPK enables TVETMARA educators to understand how ICT tools facilitate active teaching in technical and engineering courses. Incorporating technology applications such as videos in teaching and learning promotes active and creative engagement, increasing retention rates (Shabiralyani et al., 2015). ICT tools have a significant impact in bridging the gap between the classroom and real-world workplaces

through problem-based learning and project-based learning approaches. TVETMARA instructors have the potential to enhance student engagement and enrich the learning experience via the use of multimedia resources sourced from the Internet, including videos and PowerPoint presentations.

Previous research supports using mixed presentation, combining PowerPoint, video clips, written illustrations and practical examples as students prefer when learning subjects like Process Control in engineering education (Jwaid et al., 2014). Furthermore, a study by Khairul Anuar et al. (2022) indicates that instructional videos used in problem-based and project-based learning improve design and craftmanship skills, critical thinking abilities and learning experiences. Thus, the selection of ICT tools used by TVETMARA educators in active teaching creates a dynamic and personalised learning environment tailored to each student's specific needs.

Drawing insights from Theme 1, the theory of situated learning accentuates the inherently contextual nature of learning. Technology Knowledge (TK) plays a pivotal role in STEM education, with simulators and virtual reality tools enriching the learning experience. These tools are not mere adjuncts but become foundational in the community of practice for STEM educators, moulding genuine learning experiences. A robust learning environment is crafted by integrating technological knowledge with scientific inquiry. This harmonious melding is reflected in practices that use technology to make learning more relatable through vivid representations, analogies, and demonstrations.

The situated learning theory provides a lens through which we can understand the emphasis on TK within the TPACK framework for STEM teaching. It underscores fruitful teaching methodologies' intertwined, participatory, and comprehensive attributes.

Delving deeper into Theme 1, the significance of ICT in TVETMARA's curriculum emerges, accentuating its alignment with industry requisites and educators' adeptness with these tools. The situated learning theory underscores the value of genuine environments, tools, and communities of practice. TVETMARA educators embed technology seamlessly into their teaching as connoisseurs in their domain. This alignment with industry standards ensures that external forces keep the community's practices uninfluenced. It is evident that TVETMARA's focus on ICT and alignment with industry requirements embody the tenets of situated learning, where authentic, dynamic, and community-driven contexts are pivotal for optimal learning.

Further, Theme 1 highlights the importance of Technology Pedagogical Knowledge (TPK) in enabling TVETMARA educators to weave ICT tools into active pedagogies, enriching learning experiences. Situated learning theory emphasises numerous facets, including the centrality of tools in a community, the symbiosis between knowledge and its real-world application, and the significance of dynamic, authentic learning environments. This is seen in problem-based and project-based learning practices, which ground the learning process in real-world scenarios.

In summary of Theme 1, TVETMARA educators' strategic integration of ICT tools in teaching aligns closely with the principles of situated learning theory. The overarching theme is the nexus between technology, pedagogy, and context, emphasising authentic, participative, and dynamic learning experiences.

5.1.2 Theme 2: Organisation Support

The findings in Theme 2 emphasised the importance of organisational support in integrating ICT, specifically in STEM teaching as its pedagogical practice, which is consistent with previous studies (Ertmer & Ottenbreit-Leftwich, 2010; Ryan & Bagley, 2015; Salehi &

Salehi, 2012) . As an organisation, TVETMARA assists its educators in overcoming challenges in integrating ICT in STEM teaching by addressing ICT infrastructure adequacy, educational leader support, and professional development ICT training.

From the lenses of TPACK, there is sufficient support for the development of Technological Knowledge (TK) of TVETMARA educators provided by the organisation. ICT infrastructure adequacy addresses this, which provides a foundation for successful ICT integration in STEM teaching. The increased number of labs and teaching devices have become key initiatives of TVETMARA to achieve high-quality teaching and learning. This is consistent with a previous study by Salehi and Salehi (2012) that suggests insufficient technical support, low access to the Internet, and ICT were significant barriers to preventing teachers from integrating ICT into teaching. Moreover, the Digitalisation Program indicates TVETMARA's initiative to support educators with the necessary ICT tools and skills.

In contrast, allocating a budget for new ICT tools and enhancements to existing infrastructure reflects an organisational commitment to technology. This also includes specific tools such as the AutoCAD simulator and the need for regular updates and licensing, which indicates how the TVETMARA curriculum aligns with Technological Content Knowledge (TCK). This can be seen from the nature of the TVET curriculum developed by the strong technological competence (Dayangku Suraya Awang Jafar et al., 2020).

The findings in Theme 2 highlight the significant role of educational leaders, including administrators and department heads, in assisting TVETMARA educators to integrate ICT in STEM teaching. They support TVETMARA educators by providing necessary resources for ICT integration, offering motivation to encourage the use of ICT and facilitating professional development training that assists educators to become proficient with ICT tools. Moreover, the

encouragement and recognition of TVETMARA educators' efforts by their educational leaders can be seen through developing digital teaching materials as a part of their Key Performance Indicators (KPI). As highlighted in a study by (Dwivedi & Joshi, 2021), the management approach to ICT integration in educational institutions such as higher education institutions should be through leadership responsibilities. Whereas it is the role of educational leader to focus on curriculum, and head of departments to ensure the relevant ICT-enabled infrastructure and implementation are in place.

The findings in Theme 2 are also supported by another study by Tondeur, Coopert and Newhouse (2010) that suggests schools should focus on school characteristics to promote educational change, particularly ICT integration. Schools should invest in infrastructure support, leadership planning and innovativeness to create a conducive environment for ICT integration. Hence, the discussion above is relevant to the contextual knowledge (XK) in TPACK, where the setting of the educational institution of TVETMARA develops TVETMARA educators' knowledge in integrating ICT in STEM teaching. The blended knowledge of resources and supports provided by TVETMARA affects teaching with ICT to facilitate a better understanding of the context around TVETMARA educators. As the examined context is frequently missing in TPACK (Rosenberg & Koehler, 2015), findings in theme 2 in this study fill up the knowledge gap of TPACK.

The findings in Theme 2 emphasise the significance of professional development training in ICT within STEM teaching in the TVETMARA education system. As TVETMARA acknowledges the importance of equipping its educators with the necessary skills and knowledge to integrate ICT tools, TVETMARA provides professional development training in ICT for its educators under the Digitalisation Program. This aligns with past studies (Tondeur et al., 2016)

that agree that teacher professional development is necessary for educational change, such as the effective application of technology to enhance learning.

Despite efforts to conduct training, TVETMARA appears to be lacking in providing effective ICT training that focuses on empowering pedagogical knowledge, which is TPK in TPACK. This is evidenced from the interview excerpts, where training is more geared towards the technical aspects of using various tools and software, such as PW4 wiring, solar energy systems and AutoCAD than on integrating these tools effectively into teaching. A study by Mwangi and Khatete (2017) examined the professional development needs of teachers in Kenya, focusing on their pedagogical ICT integration needs. It revealed that most teachers felt professional development approaches did not adequately equip them for independent ICT usage in schools. Harris and Hofer (2017) highlighted the strong influence of local context and culture on the appropriation of the TPACK construct and suggested that professional development efforts should be tailored to the specific needs and contexts of individual teachers and schools.

In theme 2, situated learning theory emphasises the significance of learning within authentic environments and contexts. TVETMARA's endeavours to furnish adequate ICT infrastructure, up-to-date laboratories, and teaching devices are instrumental in facilitating situated learning by creating an authentic learning environment. The active involvement of educational leaders in providing resources and facilitating ICT integration plays a pivotal role in fostering a communal environment for knowledge sharing and collaborative learning. Additionally, the theory of situated learning underscores the importance of educational leaders in providing resources and facilitating ICT integration. It is essential to contextualise professional development training in ICT by integrating tools into unique teaching scenarios and emphasising the holistic integration of technology into teaching. While TVETMARA's strategies align with

the principles of situated learning, it is critical to focus on the context in which educators operate and underscore the holistic integration of technology into teaching.

5.1.3 Theme 3: Peer Collaboration

Grounded in the Situated Learning Theory, the findings from the study' Peer Collaboration' accentuate the central role of learning in context as a fundamental principle where collaboration in establishing an enriching and supportive milieu for educators engage with the challenges and opportunities arising from the integration of ICT tools into their pedagogical attempts in STEM teaching. In this context, collaborative learning and technical assistance emerge as catalysts contributing to the knowledge-building and skill development among TVETMARA educators in effectively harnessing ICT technology. This, in turn, leads to the facilitation of more immersive and successful educational experiences within the TVETMARA setting. Moreover, TVETMARA educators acquire TPACK knowledge and develop a sense of identity within a TVETMARA community of practice.

These findings harmonise seamlessly with prior research, notably the study by Dong and Xu (2019), which identifies peer support as an essential predictor of active teacher engagement within STEM domains. Consequently, the study advances the notion that fostering a collective awareness can significantly impact increasing teachers' involvement in STEM teaching. Moreover, educators perceive their peers as valuable sources of insights, particularly in mastering advanced technological tools (Stevenson, 2004).

The study vividly illustrates how TVETMARA educators embody the significance of collaborative learning and support in integrating ICT tools into their pedagogical practices of STEM teaching. This collaborative learning environment among educators offers a platform for the mutual sharing of knowledge, expertise, and best practices for integrating ICT. Functioning

as a dynamic impetus, this collaborative approach facilitates individual educators in exploring novel ICT tools and drives them toward their adoption. Educators are exposed to innovative technological solutions through the discourse of experiences and insights, such as the interactive teaching feature' Class Point' within PowerPoint. This echoes the findings of (Hanimastura, Hairulliza and Tengku Siti Meriam (2016), whose research suggests that knowledge-sharing endeavours among TVET instructors significantly contribute to further developing their existing knowledge base. Thus, the study intricately underscores how the Situated Learning Theory manifests in the symbiotic relationship between collaborative practices, technology integration, and educator advancement within the field of TVETMARA.

From the lenses of TPACK, collaborative activities and technical support in the TVETMARA community develop TPK, TCK and TK of TVETMARA educators by facilitating the exchange of expertise, experiences, and strategies related to technology integration in teaching and learning. It provides a platform for TVETMARA educators to share their knowledge and experiences with different ICT tools (TK) and how they are effectively used in TVETMARA curriculum contexts (TCK). This collaboration extends to sharing teaching materials, including lesson plans, videos, and modules. Sharing these resources fosters a community of TVETMARA educators who collectively improve their TPK, TCK and TK and enhance the quality of teaching. This is aligned with the previous study that collaborated project resulted in significant teacher gains in technology skills, new knowledge in the use of simulations in teaching, positive changes in pedagogy, and increased content knowledge (Allan et al., 2010), which contribute to professional development (J. Harris & Hofer, 2017) and the growth of innovative teaching practices.

5.1.4 Theme 4: Pedagogical Practices

Results from the Theme Pedagogical Practices, when analyzed through the lens of Technological Pedagogical Content Knowledge (TPACK), show how STEM teaching may be strengthened and improved through the use of ICT tools in the TVETMARA setting. TPACK is a framework that emphasises the interplay between three essential components, technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), to create effective teaching practices where ICT facilitates learning. TVETMARA educators in this qualitative study demonstrate the dynamic interplay between technological, pedagogical, and content knowledge, as envisioned by the TPACK framework. It underscores how educators' proficient use of ICT tools enhances STEM teaching practices, creating engaging and effective learning experiences for TVETMARA students. This is evidenced through the usage of various ICT tools such as CAD software, Microsoft Teams, Google Classroom, and Multisim for enhancing STEM teaching, which are employed to conduct practical simulations, deliver engaging lessons, administer assessments, and facilitate communication. It showcases their TPACK in their ability to select, adapt, and effectively utilise these tools. This contradicts previous studies that TVET only focuses on TK (Hamidah & Fitri Suraya, 2022) and is less important in PK (Junnaina & Hazri, 2014) due to the TVET curriculum that looks more into machine operations and hands-on activities. A study by Mutanga, Nezandonyi and Bhukuvhani (2018) also found that most engineering lecturers were competent in their knowledge about individual components of TPACK, especially on content and technology, but lacked their pedagogical knowledge. The findings from this qualitative study give insights that have yet to be captured by previous studies that were conducted quantitatively. The findings imply that TVETMARA educators used elements of best practices of ICT integration in STEM teaching.

Furthermore, the findings vividly portray the intersection of technological, pedagogical, and content knowledge. TVETMARA educators leverage their understanding of the subject matter (CK) and pedagogical strategies (PK) to effectively integrate ICT tools (TK) into their teaching practices. For instance, using CAD software to teach Mechanical Drawing and Design by TVETMARA educators allows students to apply their knowledge while enhancing visual understanding practically. Similarly, employing Microsoft Teams and Google Classroom (TK) assists educators in managing assessments, organising teaching materials, and providing feedback (PK) for subjects like Electric Circuit classes. This aligns with the research conducted by Istiningsih (2022), which demonstrates that the incorporation of Information and Communication Technology (ICT) into the Technological Pedagogical Content Knowledge (TPACK) framework yields favourable outcomes for educators in Indonesian Vocational High Schools, particularly within the context of the Fourth Industrial Revolution. However, the study suggests providing more effective and professionally targeted ICT support and training to increase the teachers' competency.

In the theme 'Pedagogical Practices', situated learning theory emphasises that knowledge and learning are deeply embedded in the context of their use. TVETMARA's STEM teaching practices mirror real-world applications using tools like CAD software, Microsoft Teams, and Google Classroom. This qualitative approach highlights the contextual nature of knowledge, highlighting the dynamic interplay of TK, PK, and CK within TVETMARA. Platforms like Microsoft Teams and Google Classroom foster a sense of community, allowing educators and students to share resources, engage in discussions, and collaborate on projects. The findings suggest a continuous evolution and adaptation in TVETMARA's approach to teaching as educators adapt to new tools and strategies and refine their pedagogical practices. The

recommendation for more support and tailored ICT support aligns with situated learning principles. Overall, TVETMARA's integration of ICT tools in STEM teaching practices aligns with situated learning theory principles, exemplifying both embedded and situated learning.

5.1.5 Theme 5: Lesson Preparations

The significant finding in Theme Lesson Preparation is how TPACK and contextual knowledge (XK) play a crucial role in preparing lesson plans and teaching aids using ICT in STEM teaching. TPACK and XK elements can assist TVETMARA educators in aligning pedagogical strategies and ICT tools with TVETMARA curriculum goals and learning objectives. TPACK integration is evident in the well-structured lesson plan that leverages ICT to enhance pedagogical practices and deliver TVETMARA curriculum content effectively. This finding agrees with Janssen and Lazonder (2015), who adapt the TPACK framework to design lesson plans for preservice and in-service high school biology teachers. Fitness content, pedagogy and technology knowledge (TPACK) are also demonstrated during class observations. This finding is in contrast with the findings of Rahmawati, Suryani, Akhyar and Sukarmin (2021). The study found that the lesson plan prepared by the Vocational high school teachers in Indonesia and the lesson implemented showed less TPACK - fitness integration technology in learning with strategies and objectives of the curriculum. The inconsistency with the findings can be explained by the sample of respondents who were vocational building engineering teachers with non-ICT knowledge and less usage of technology in vocational learning in Indonesia. In contrast, TVETMARA educators have the ability to weave together content, pedagogy and technology in a cohesive manner to create a robust educational experience.

The examples and quotes from TVETMARA educators illustrate how contextual knowledge contributes to effective instructional planning. TVTEMARA educators highlight how

they adapt their strategies to the needs of the students and institutions. In XK, TVETMARA educators must be aware of available technology, institutions, and policies (Mishra, 2019). Past studies (Ghavifekr et al., 2016; Salehi & Salehi, 2012) agree that technical support and access to the Internet and ICT are considered major barriers to discourage teachers from integrating ICT in classrooms. The finding in this study indicates that TVETMARA educator's knowledge of the technology supported by the institution included in the TVETMARA curriculum and industry assists in their lesson planning and teaching aid planning. A reviewed study by Rosenberg and Koehler (2015) emphasized the importance of context in the TPACK framework and the development of measurement in context. Based on the conceptual framework of context in TPACK, this study employs meso or school factor as its context. School factors are those in the school settings where the learning environment is found. The findings in this study give insight into contextual knowledge in the TPACK framework by examining the TVETMARA educators' awareness of available technologies and institutional constraints.

The study on Theme Lesson Preparation and integrating Technology, Pedagogical, and Content Knowledge (TPACK) and Contextual Knowledge (XK) in TVETMARA's STEM teaching practices is related to situated learning theory. It emphasises learning in context, authentic activities, contradictions and comparisons, dynamic interactions, barriers and enablers, community of practice, and the school factor. TVETMARA educators, as they share knowledge, adapt strategies, and incorporate available technological tools, are forming a community of practice. Their collective understanding and practices related to the TVETMARA curriculum, tools, and objectives represent shared knowledge within this community. Additionally, the study highlights the importance of incorporating TPACK and XK in TVETMARA's teaching practices,

emphasising the importance of contextual knowledge, authentic activities, and the dynamic interplay of various knowledge types within specific environments.

5.1.6 Summary of Qualitative Discussions

Overall, TVETMARA educators adeptly incorporate ICT tools into their teaching, mirroring the core tenets of situated learning theory. This approach hinges on the intricate relationship between technology, teaching methodologies, and the surrounding environment, aiming for authentic and evolving learning experiences. The strategies observed in TVETMARA resonate with situated learning principles. However, to fully encapsulate this alignment, professional training must be immersed in the actual contexts they navigate. The goal should be a comprehensive fusion of technology into educational practices, moving beyond mere technical proficiency. In essence, when assessing TVETMARA's lesson planning and the amalgamation of TPACK and XK, it is evident that these practices can be interpreted within the situated learning framework. The pivotal roles of environment, real-world application, and the cohesive blending of diverse knowledge realms are all in harmony with the foundational beliefs of situated learning.

5.2 Quantitative Discussions

The quantitative phase consisted of content and construct validation of the SITI. The content validation was conducted in the Development Phase (Phase Two) where two panel experts validated using Content Validation Index (CVI). Based on CVI analysis, five constructs and forty-two items proposed for initial SITI. Subsequently, the study employed factor analysis as the statistical method for establishing the SITI's construct validity (El-Den et al., 2020; Zhou, 2019)

The second stage of the factor analysis test is Confirmatory Factor Analysis (CFA). which is to confirm a specific hypothesized factor structure (Jackson et al., 2009). To answer the third research question, which is the STEM ICT Teaching Inventory, a reliable and valid instrument, the study conducted a factor analysis test of EFA and CFA and reliability, convergent validity and discriminant validity to assess construct validity.

The validation analysis process in the study employed statistical approaches to establish content and construct validation. Content validation based on panel expert reviews was calculated using the Content Validation Ratio (CVR). Construct validation was established through convergent validity and discriminant validity using factor analysis. These strategies have been commonly reported in previous studies by Muhamad Saiful Bahri (2019; Nur Farhana et al. (2020 and Wahono and Chang (2019). For instance, the authors conducted content validation to verify scales in their study. Whereas Whereas (Girela-López et al., 2022; Onwezen & Bartels, 2013; Wahono & Chang, 2019) conducted construct validation using EFA and CFA.

In the current study, content validation was performed using descriptive analysis and CVR through expert reviews and face validation was established through a qualitative approach by practitioners. Combining both experts' and practitioners' reviews performed a rigorous process to analyse the content of the STEM ICT Teaching Inventory. This is in contrast to past studies (Nur Farhana et al., 2020; Wahono & Chang, 2019) that performed content validation using experts only. The process of establishing construct validity consists of EFA, CFA and reliability analysis. The study presents a systematic way of developing and testing new instruments.

Moreover, no instrument existed in the field of STEM teaching that investigates contextual factors that influence STEM teaching with ICT integration in the context of TVET. In

contrast, past studies that developed STEM instruments employed the CCA (Karpudewan et al., 2022) extraction method and the Varimax analysis (B. Yildirim & Sahin Topalcengiz, 2019) rotation method. In contrast, this study used Principal Axis Factoring as its extraction method with Promax analysis as its rotation method. Moreover, the current study is an empirical example of employing sequential exploratory mixed methods for instrument development. It also developed a reliable and validated instrument to measure STEM teaching practices incorporating ICT in TVET from contextual factors.

5.2.1 Exploratory Factor Analysis

Factor analysis is employed to explore and confirm the underlying structure of a set of constructs and items that measure the contextual components in STEM teaching integrating ICT (Taherdoost et al., 2022). It helps to identify the relationships between items and the five constructs that might influence TVETMARA educators in STEM teaching practice. Firstly, the study conducted the Exploratory Factor Analysis (EFA). EFA aims to uncover the underlying structure or SITI ‘s construct that explain the patterns of correlations or covariation among the items (Watkins, 2018). The goal in using EFA is to determine how many contextual constructs are responsible for the relationships among the items.

EFA analysis formed a five-factor model namely ICT Selection, Organisational Support, Peer Collaboration, Pedagogical Practices and STEM Teaching. This study supported past studies in STEM Education that employed EFA to validate the constructs that newly developed instruments (Halim et al., 2018; Karpudewan et al., 2022; Wahono & Chang, 2019). However, SITI employed Principal Axis Factoring and Promax rotation compared to past studies that used Principal Component Analysis and Varimax rotation. The EFA results remained with 32 items

responded to the literature and the qualitative findings on STEM teaching practices integrating ICT.

All items in ICT Selection were retained in EFA study. These items fit the definition of how technology knowledge becomes essential for TVET instructors (Fahadi & Khan, 2022; Hamidah & Fitri Suraya, 2022; Mutanga et al., 2018). Moreover, selected ICT tools assist TVETMARA educators to implement STEM teaching. All items in Organisational Support (8 items)and Peer Collaboration (7 items) also retained in EFA analysis. This indicates that the importance of organisational support such as TVETMARA in tackling challenges face by its educators in integrating ICT, specifically in STEM teaching as its pedagogical practice (Ertmer & Ottenbreit-Leftwich, 2010; Ryan & Bagley, 2015; Salehi & Salehi, 2012) . It focuses on improving ICT infrastructure, providing support from leaders, and offering professional development training. Additionally, items in Peer Collaboration identifies peer support as an essential predictor of active teacher engagement (Dong et al., 2019; Hanimastura Hashim et al., 2016) within STEM domains. However, the removal of two items in Pedagogical Practices does not reflect innovative teaching(Goh & Sigala, 2020; Lukychova et al., 2022). It suggests a bigger role for Computer Aided Design beyond showcasing real life or workplace situations. Similarly, using ICT for students' attendance is not defined as innovative pedagogical practices. Interestingly, Lesson Preparation as one of the contextual factors that contribute to ICT integration in STEM teaching was removed. It suggests that planning a lesson that incorporates ICT in STEM teaching emphasizes on the selecting of ICT tools and collaborating with peers become two elements that defined lesson preparation itself (König et al., 2020; Schipper et al., 2020) .

5.2.2 Confirmatory Analysis

The SITI is a newly developed instrument designed to assess the contextual factors that influence the integration of ICT in STEM teaching, particularly for TVETMARA educators. The table reflects the results of a Confirmatory Factor Analysis (CFA), which helps in validating the SITI's structure by examining the relationships between SITI items and constructs. There are five aspects that influence ICT integration in STEM teaching highlighted in confirmatory factor analysis (CFA) results.

The construct of '*ICT Selection*' had factor loadings ranging from 0.698 to 0.924 which indicates that item Ise1 to item Ise10 significantly contribute to the construct. The average variance extracted (AVE) of 0.652 suggests a good level of convergence. In other words, item Ise1- Ise10 adequately reflects the activities of ICT selection in STEM teaching based on TVETMARA curriculum and teaching method . High factor loadings, such as Ise6 (0.924) – ' *I select ICT which aligns with my teaching method (problem based learning)*' and Ise8 (0.926) – '*I select ICT which aligns with my teaching method (inquiry based learning)*', suggest strong item reliability and indicate that TVETMARA educators emphasis on selecting ICT tools that assist them in their teaching practices focusing on problem solving and inquiry learning. This is supported by past studies that utilized technologies in problem-based learning and inquiry based learning to support and improve in STEM teaching (Deák et al., 2021; Khairul Anuar et al., 2022; Muzana et al., 2021). Thus, items in the *ICT Selection* demonstrate the educators' capability to select appropriate digital technologies and match with pedagogical strategies effectively, which are key components of TPACK. In line with previous studies, Technology Knowledge (TK) becomes a dominant component of TVETMARA educators' TPACK (Fahadi & Khan, 2022; Hamidah & Fitri Suraya, 2022; Mutanga et al., 2018).

With an AVE of 0.701 and factor loadings between 0.798 and 0.863, the construct '*Organisational Support*' shows that support received from TVETMARA is crucial for educators to be successful in integrating ICT in STEM teaching. High factor loadings, such as OS2 (0.863) – '*My organisation provides ICT based on technical field needs*' and OS4 (0.837) – '*My organisation provides sufficient lab facilities*', highlight that institutional resources, training, and overall support are integral to enable TVETMARA educators to incorporate ICT into their STEM curricula. The items in '*Organisational Support*' relate to the broader context of TPACK. The support systems built by TVETMARA through professional training and educational leaders' role provide essential scaffolding for educators to build their TPACK in the context of STEM teaching. This is consistent with past studies which suggested that school support can enhance teachers' TPACK(Dong et al., 2020) and lack of support becomes a barrier in the use of ICT in teaching (Nikolopoulou & Gialamas, 2016).

In *Peer Collaboration*, the factor loadings for this construct range from 0.729 to 0.898, and the AVE is 0.68. These results suggest that collaboration among educators plays a significant role in the adoption of ICT for STEM teaching which in line with past studies (Dong et al., 2019; Hanimastura Hashim et al., 2016). The strong factor loadings, particularly for items PC4 (0.897) – '*I share STEM teaching digital materials with TVETMARA peers*' and PC5 (0.898) – '*I share STEM teaching digital assessment materials with TVETMARA peers*', demonstrate the importance of peer support and collective problem-solving in enhancing the ICT teaching experience. The items in *Peer Collaboration* underscore the social and collaborative aspects of learning to use technology effectively which emphasize in TPACK-related professional development (Mujallid, 2021; Njiku et al., 2021). As Situated Learning Theory posits that

learning occurs most effectively when it is embedded within its context. Situated Learning Theory posits that learning occurs most effectively when it is embedded within its context.

In SITI, the constructs *Organisation Support* and *Peer Collaboration* highlight how the specific context (e.g., TVETMARA environment, collaboration with peers) shapes the integration of ICT in STEM teaching in TVETMARA. The Peer Collaboration dimension directly aligns with the importance of communities of practice, showing that educators learn to integrate ICT by working together, sharing best practices, and solving problems collaboratively. The high factor loadings for items in this dimension (e.g., PC4 and PC5) reflect the importance of a supportive learning community, resonating with the situated learning perspective. In relation with Situated Learning, it emphasizes that learning to integrate technology is not just about acquiring skills but also about engaging with the social and organizational context in which teaching occurs(Scavarelli et al., 2021).

'*Pedagogical Practices'* exhibits factor loadings from 0.656 to 0.876, with an AVE of 0.894, indicating a very high level of construct validity. Items like PP8 (0.876)-'*I use ICT based task for my students' assessment*' and PP7 (0.843) – '*I use ICT to differentiate my students' learning styles*' show that effective pedagogical strategies are vital in the integration of ICT into the teaching process. TVETMARA educators' ability to adapt their teaching methods in light of new digital technologies is reflected in the strength of these items. Moreover, TPACK encourages educators to adapt their teaching methods to incorporate technology meaningfully for effective learning. This contradicts previous studies that TVET only focuses on TK (Hamidah & Fitri Suraya, 2022) and is less important in PK (Junnaina & Hazri, 2014) due to the TVET curriculum that looks more into machine operations and hands-on activities

In '*STEM Teaching*' construct has an AVE of 0.849, with factor loadings from 0.832 to 0.885. This suggests that the construct reliably measures the specific pedagogical practices related to STEM education. High loadings, such as ST2 (0.885) –'*I use image from internet to show real life/workplace situations'*, show that educators are effectively incorporating ICT into application of real problem solving , reinforcing the instrument's reliability in assessing authentic STEM-specific teaching approaches. Relating to Situated Learning Theory which emphasizes learning through authentic, real-world tasks, the STEM Teaching dimension (high loadings such as ST2) captures the application of ICT in authentic STEM teaching scenarios, reflecting the practical, situated nature of learning(Stansberry, 2017). This shows that educators are not just theoretically knowledgeable about ICT integration but are applying these skills in real teaching contexts, which is a core principle of Situated Learning.

In conclusion, the CFA factor loadings support the validity of the STEM ICT Teaching Inventory as a robust tool to evaluate the five contextual factors impacting ICT integration in STEM education for TVETMARA educators. Each construct shows strong reliability and contributes to understanding how various factors like organisational support, peer collaboration, and pedagogical practices affect the use of ICT in teaching. Items and constructs of STEM ICT Teaching Inventory are highly relevant to both the TPACK and Situated Learning Theory, as it aligns with the core principles of these theories in the context of ICT integration in STEM education.

The iterative CFA process significantly impacts the construct validation of the STEM ICT Teaching Inventory by systematically enhancing the model fit and thereby reinforcing the validity of the constructs being measured. Construct validation refers to the degree to which a test or inventory accurately measures the theoretical constructs it is intended to measure. In this

process, the adjustments made to improve the model fit directly contribute to the validation of the inventory by addressing sources of misfit that could undermine the reliability and accuracy of the measurement.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This section provides the study's conclusion by reviewing the summary of the results in Chapter 5. The summary gives an overview of the research background and problem and

discusses the key results based on the research questions. Additionally, Chapter 6 indicates the study's implications, summarizes limitations and suggests recommendations for future research.

6.2 Summary of The Results

Using information from the STEM domains has become more essential in addressing workplace problem-solving challenges (Asunda, 2014; Jang, 2016). In light of these conditions, Technical and Vocational Education and Training (TVET) has the ability to function as an atmosphere supportive of the advancement of STEM-related information. The capacity to proficiently use knowledge obtained from many disciplines is a crucial need for students enrolled in the Technical and Vocational Education Training (TVET) program (Dixon & Hutton, 2016; Reeve, 2016). For example, Project-based learning (PBL), a widely used instructional approach in TVET, plays a significant role in promoting the progress of STEM education. Additionally, addressing STEM teaching in the context of current workplace issues may increase its relevance and connectivity (Asunda, 2014; Dixon & Hutton, 2016; Jang, 2016).

In STEM teaching, ICT becomes a valuable teaching aid for educators to support effective teaching. Past studies have shown the positive outcomes of integrating ICT in the classroom (Aslan & Zhu, 2017; Baharin et al., 2018; Krajcik & Delen, 2017; Yang & Baldwin, 2020a). Technology tools and resources enhance students' learning experiences and provide opportunities for interactive and dynamic learning. Though integrating ICT is incorporated into the pedagogical practice of TVET educators (Chan & Fitri Suraya, 2019; Hamidah & Fitri Suraya, 2022) still lacked ICT knowledge and pedagogical knowledge (K. Ismail et al., 2017). Moreover, ICT and pedagogical skills are needed for teachers to be innovative in teaching and learning (Yasak & Alias, 2015).

Based on scholarly discussion, TPACK is a framework that emphasizes the integration of three types of knowledge (Content Knowledge, Pedagogical Knowledge, and Technology Knowledge) important for effective teaching in a technology-enhanced learning environment (Mishra & Koehler, 2006) such as TVET. It suggests that educators need to know not only their subject matter (technical and engineering) and how to teach it (STEM teaching) but also how to leverage technology (ICT) appropriately to enhance learning. However, one essential knowledge yet to be discussed in education research and TPACK (Rosenberg & Koehler, 2015) is how contextual knowledge contributes to the effective use of technology in teaching.

The purpose of this study is to gain a better understanding of the contextual factors that are related to educational organization (TVETMARA) through the development and validation of the STEM ICT Teaching Inventory (SITI). The aim of the study was to address three research questions :

RQ1 : 1) How do TVET MARA educators integrate ICT in their STEM teaching from the lens of TPACK?

i) What are the attributes of ICT teaching practices of TVETMARA educators in STEM teaching for the development of SITI?

RQ2 : To what extent is the STEM ICT Teaching Inventory (SITI) instrument reliable to measure TVETMARA Educators' ICT integration practices in STEM teaching?

RQ3 : Which model is the most suitable for describing and explaining TVETMARA educators' ICT integration practices in STEM teaching?

The development of SITI occurred in three stages, using a sequential exploratory mixed-method approach. The first stage included conducting a semi-structured interview with a cohort of 10 educators from the TVETMARA program. Class observation with eight educators was conducted to triangulate the data from the interviews, followed by the analysis of four lesson plans. Based on thematic analysis, five themes were generated from the qualitative study: ICT Selection, Pedagogical Practices, Lesson Preparations, Organisation Support and Peer Collaboration. In the study's second phase, the items pool was generated using three components: a) using themes from the qualitative analysis to develop constructs, b) using codes to describe the constructs, and c) using codes and quotes to generate items. As a result, the initial SITI instrument comprised of five constructs namely ICT Selection, Pedagogical Practices, Lesson Preparations, Organisation Support and Peer Collaboration. The instrument consisted 42 items rated on a 7-point Likert Scale from Strongly disagree (1), Disagree(2), Somewhat disagree(3), Neutral(4), Somewhat agree(5), Agree(6) and Strongly agree(7). In the third phase of the study, which was the quantitative phase, SITI was assessed for content validation, construct validation and reliability analysis. The content validation was based on experts' review with the mean of items in five constructs ranging from 3.5 to 5.00 and I-CVI = 1.00. All the items in the proposed SITI were retained and content validated. Before conducting construct validation, the instrument was explored for identifying latent constructs and the underlying structure of SITI using EFA and CFA. Exploratory Factor Analysis (EFA) was employed in order to explore the underlying structure of items and the potential factor structure of dimensions in the STEM ICT Teaching Inventory (SITI).

Three criteria were used for factor structure evaluation: failure to load, items loading and cross-loading. Using EFA analysis, this study found that 32 STEM (ICT) Teaching Inventory

items produced five dimensions: ICT selection, Organisation Support, Peer Collaboration, ICT in Pedagogical Practices and STEM teaching. The dimension of Lesson Preparation was excluded from the study owing to the low factor loadings shown by its components.

This correlation indicates that items in the dimension Lesson Preparation are related to items in the dimension ICT selection and dimension Peer Collaboration. In this study, CFA was used to show how well the hypothesized model from EFA explains the observed patterns and to test the goodness fit of the model. The resulting model retained five dimensions and 32 items. After modification of indices, ten pairs of error terms were covaried in three rounds, and the model reached the criteria of goodness-of-fit indices with the final model result in CFI = 0.938, TLI = 0.930, SRMR = 0.0426 and RMSEA = 0.072. In developing SITI, construct validation was established using convergent and discriminant validity. The five dimensions and 32 items used for the present study have the required convergent validity since the average variance-extracted value was above the threshold value of 0.50.The assessment of discriminant validity in the research was conducted using the Fornell and Larcker Criterion as well as the Heterotrait-Monotrait (HTMT) Ratio.

When assessed using the HTMT ratio, all ratios were less than the required limit of .85 (Henseler et al., 2015), which indicated that the discriminant validity was established. It is argued that the present theoretical framework of SITI makes a unique contribution to the field of learning sciences and technologies in enhancing our understanding of key elements within the understudied contextual factors, particularly in the context of TVETMARA. Future research involving replication and generalization of this self-assessed instrument will corroborate and extend the findings of the present thesis.

6.3 Implications of The Research

Past studies have examined various issues in STEM teaching from the lens of TPACK. This study brought together theory and research in STEM teaching, ICT integration and TVET to examine and develop SITI, which consists of five components in contextual factors. A newly developed self-report instrument for TVETMARA educators, known as the SITI instrument, has been developed based on the findings of factor analysis derived from the survey data.

This instrument can support future research to produce an understanding of TVETMARA educators' knowledge of contextual factors and create an effective ICT-enhanced environment. This section draws implications based on the findings and discussions previously presented in Chapter Four and Chapter Five. This section provides an explanation of the theoretical, methodological and practical implications of this study.

6.3.1 Theoretical Implications

Based on the gaps that have been found in the literature, the present study addresses the contribution to the theoretical gap which it attempts to fill in. This study discusses the limited research on using ICT in STEM teaching by introducing the SITI instrument. Specifically, the SITI instrument captures the key contextual factors that influence the use of ICT in STEM classrooms. Hence, it provides a better understanding of how ICT can be effectively integrated into STEM teaching in TVETMARA.

In this study, TPACK and Situated Learning Theory are used as the underpinning theories to develop the constructs and items in SITI. As stated in the first research question, how do TVETMARA educators integrate ICT in their STEM teaching from the perspective of

TPACK framework. It is further analyzed by looking into the activities that develop SITI instrument. In the initial phase of SITI development, TPACK guides the data collection, data analysis process of semi-structured interview, class observations and lesson plan analysis. From the thematic analysis, there are five key components that contribute to the utilization of ICT in STEM teaching of TVETMARA educators namely ICT selection, Organisation Support, Peer Collaboration, Pedagogical Practices and STEM Teaching. These five factors represent the contextual knowledge of TVETMARA educators in their digital technologies' integration in STEM teaching.

The development of SITI as a self-assessed instrument will be a complementary measurement in SPMa (Standard Pendidik MARA) system. It measures the contextual knowledge of TVETMARA educators in their digital technologies' integration in STEM teaching. Contextual knowledge becomes a critical component to ensure success in teaching using technology. In the literature, less discussion on contextual knowledge of teachers in STEM teaching integrating ICT in TVET educational settings. Hence, the study extends the current understanding of STEM teaching with ICT by examining the constructs of contextual factors. Moreover, it confirms TPACK and Situated Learning as the theoretical underpinnings that ground SITI conceptual framework.

From the TPACK literature analysis, the first key finding concludes that Technological Knowledge (TK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) become dominant components that shape up TVETMARA educator's contextual knowledge. In each construct of SITI shows the interaction of technology, technology content and technology pedagogy to assist TVETMARA educators in their ICT integration practices in STEM teaching. For example, in the construct of ICT Selection, choosing ICT tools

(Technology Knowledge) is influenced by the syllabus of TVETMARA courses (Technological Content Knowledge) and their teaching methods (Technology Pedagogical Knowledge). Past studies have discussed TK and TCK as critical knowledge components in TVET (Fahadi & Khan, 2022; Hamidah & Fitri Suraya, 2022; Mutanga et al., 2018) to implement STEM teaching, yet less attention has been given to the role of TPK. Based on the findings analysis, TPK captures TVETMARA educators' ability to interplay with their ICT knowledge to enhance STEM teaching. TVETMARA educators take great consideration in ICT' affordances of their students in order to create a technology supportive learning environment of their students. Thus, this study expands the role of TPK in TPACK research within the TVET setting by highlighting how TVETMARA educators not only integrate digital technologies based on TVETMARA curriculum and STEM teaching but also strategically utilize TPK to create supportive, student-centered learning environments that enhance ICT integration in STEM teaching.

From the perspective of Situated Learning Theory, it emphasizes learning in authentic contexts through social interaction and participation (Lave, 1996). However, literature often overlooks how technology mediates these learning processes in vocational and technical education settings (Lensjø, 2020), such as TVETMARA.

Bridging the Situated Learning Theory gap, the findings highlight how TVETMARA educators not only select ICT tools based on TVETMARA curriculum content and pedagogical practices, but also consider students' technological affordances to foster supportive learning environments. This demonstrates that effective ICT integration is not just about the alignment of technology with content and pedagogy but also about creating authentic, contextualized learning experiences, consistent with Situated Learning Theory principles(Hassan et al., 2021). Moreover, in the five constructs of SITI, TVETMARA educators implement active teaching and learning to

create learning opportunities that reflect the real-world challenges and tasks in enhancing students' practical skills. For TVETMARA educators, exploring ICT tools for their STEM teaching encouraged by their community of practice becomes an element of Situated Learning Theory. This finding is inconsistent with Situated Learning Theory that supports the principle highlights learning in social and participation (Cruess et al., 2018). Thus, by exploring the dynamic interaction of ICT, TVETMARA curriculum content, and pedagogical practices, this study expands Situated Learning Theory by showing how TVETMARA educators use digital technologies integration to fit the unique context of STEM teaching environments. This perspective underscores the importance of considering educators' adaptive use of technology as a situated practice, enhancing Situated Learning Theory's application in modern, technology-rich educational contexts like TVETMARA.

Second, this study is one of the first to consider the five contextual factors from the perspective of educational organisation into one research model as an essential role in incorporating ICT in STEM teaching. The identification of five constructs of SITI, including the aspect in each construct, adds to the understanding of the multifaced elements of contextual factors in TPACK framework. Moreover, the operational definition of each contextual factor provides a theoretical framework for understanding the scope of context in SITI.

Based on TPACK, contextual knowledge emphasizes the organisational and situational constraints that teachers work within by understanding how their organisation functions and can effect sustainable change (Mishra, 2019). However, the lack of contextual explanations in frameworks for guiding educational technology research has theoretical implications (Rosenberg & Koehler, 2015). Hence, Rosenberg and Koehler (2015) argue that contextual knowledge needs to be studied more in TPACK research.

The findings of the five constructs in SITI provide insights into the context towards support TVETMARA educators receive from the organisation to effectively teaching using ICT. Selecting ICT tools and teaching materials provided by TVETMARA assist educators in the delivery of STEM teaching. Besides that, the encouragement from the educational leader motivate TVETMARA educators to innovate and producing excellent outcomes. Hence, the findings of the study refine the definition of contextual knowledge of TPACK in the upgraded diagram of TPACK (Mishra, 2019). It extended the current understanding of contextual factors from the perspective of educational organisations in integrating ICT in STEM teaching by further explaining the constructs of the STEM (ICT) Teaching Inventory (SITI).

This study developed and validated a self-assessed instrument that measures STEM teaching with ICT tools in TVETMARA (SITI). It also captures the key contextual factors in TVET as its educational setting. The identification of five dimensions of SITI, including ICT selection, Organisation support, Peer collaboration, Pedagogical Practices and STEM teaching, adds to the understanding of the educational organisation factor level in ICT integration.

Through the lens of the TPACK framework, it identified five contextual aspects that may aid in the successful incorporation of ICT in STEM teaching among TVETMARA educators. Furthermore, the dimensions identified in the current study add to the definition of context in the research of TPACK. In the ICT selection dimension, TK, TPK and TCK play a role in assisting TVETMARA educators in selecting the appropriate ICT tools that support the delivery of the TVETMARA curriculum and active learning strategies that are used. In the context literature, the ICT selection dimension is categorised under the meso-level factor (Porras-Hernández & Salinas-Amescua, 2013) which represents factors at the educational organisation level and is defined through the cultural and organisation of the TVETMARA community. The ICT selection

dimension indicates the availability of technology supported by TVETMARA, which aligns with its curriculum and the industry's expectations to ensure the effective use of ICT in STEM teaching. This finding extends to the study by Salehi and Salehi (2012) that argued insufficient technical support and little access to ICT and the internet became significant barriers to ICT integration in the classroom. TVETMARA educators who collectively improve their TPK, TCK and TK and enhance the quality of teaching (Allan et al., 2010).

Through the lens of TPACK, the pedagogical Practices dimension of SITI shows how STEM teaching may be strengthened and improved through ICT tools in the TVETMARA setting (Istiningsih, 2022b). The use of various ICT tools such as CAD software, Microsoft Teams, Google Classroom, and Multisim for enhancing STEM teaching, which are employed to conduct practical simulations, deliver engaging lessons, administer assessments, and facilitate communication. It showcases their TPACK in their ability to select, adapt, and effectively utilise these tools.

In the Lesson Preparation dimension, TPACK and contextual knowledge (XK) are crucial in preparing lesson plans and teaching aides using ICT in STEM instruction. Elements of TPACK and XK can aid TVETMARA educators in aligning pedagogical strategies and ICT tools with curriculum goals and learning objectives (Janssen & Lazonder, 2015). It emphasises context-based learning, authentic activities, contradictions and comparisons, dynamic interactions, barriers and enablers, the community of practice, and the school factor as one contextual factor that influences TVETMARA educators' TPACK. TVETMARA educators are establishing a community of practice as they share knowledge, adapt strategies, and implement available technological tools. Thus, discussions above contributed to the understanding of

TPACK and its development in diverse classroom and school settings by investigating the nature role of context in TPACK research.

6.3.2 Methodological Implications

The STEM Education and TPACK literature are expanded through this research. This research utilised a sequential exploratory mixed method to identify the contextual factors related to the effectiveness of STEM teaching with ICT integration. Effective instrument development and validation requires a systematic and thoughtful approach to ensure the instrument's psychometric properties and suitability for its intended use. In this study, the instrument development method using three phases, including specific activities, is applied to develop a measurement construct relevant to the study's research questions and objectives. The aim of the study is to contribute towards more rigorous instrument development in STEM teaching by investigating crucial steps in the instrument development phases and pointing out specific problems associated with each step. Developing an instrument that would lead to valid and reliable results is challenging in any research field. Therefore, this study proposed methodological progress in assessing reliability, convergent validity, discriminant validity and construct development like content validity, item pool generation and pre-test conduction.

Another significant methodological implication involves choices of statistical analysis in conducting sequential exploratory mixed methods for developing and validating instruments in three phases (Creswell & Plano Clark, 2017)). In this first phase, the qualitative phase, using thematic analysis, a well-defined research question helps ensure that the analysis is focused and relevant. Gaining a comprehensive knowledge of the context and complexity offered in the data is facilitated by familiarizing the researcher with the data.

This led to thematic identification that captures the initial contextual factors (ICT Selection, Organisation Support, Peer Collaboration, Pedagogical practices and Lesson preparation) from the educational institution's perspective in the integration phase of the sequential exploratory mixed method. In the quantitative method (third phase), factor analysis is to conduct an EFA test with principal axis factoring as the factor extraction method. Promax was chosen as factor rotation aligned with the underlying validation theory to ensure SITI accurately measures the contextual constructs in ICT integration in STEM teaching. For measurement model evaluation, CFA allowed the research to evaluate the measurement model's fit to the data. In this study, the observed variables accurately represent the SITI constructs since the instrument convergent validated showed that items within the same construct are related.

In comparison with existing instruments, SITI focuses on how ICT tools is used to enhance STEM teaching with the consideration of contextual factors (TVETMARA setting). It makes SITI become relevant to assess the integration of ICT in STEM teaching. Existing instruments assess STEM teaching with technology competency in general. SITI offers more comprehensive assessment with the contextual factors. Hence, this study added to the improvement of STEM teaching practices in TVET.

6.3.3 Practical Implicatins

There are a few possibilities of how this explicit focus can be manifested in the practices of TVETMARA educators in integrating ICT into their STEM teaching. Firstly, the findings of the study confirmed that STEM teaching with ICT is a teaching practice in TVETMARA institutions with the awareness of contextual factors involved. It is implied by the teaching strategies such as problem-based learning, project-based learning, hands-on teaching and ICT

tools employed in work-related fields. This has practical implications for educators and policymakers in designing technology interventions sensitive to contextual factors. Moreover, this can inform TVETMARA curriculum development efforts to integrate STEM teaching and promote contextualized educators' knowledge.

Second, contextual factors identified by the study were confirmed to contribute to the effectiveness of ICT integration in STEM teaching. The findings highlighted five relevant contextual constructs (ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practices and STEM Teaching) that enable TVETMARA educators to leverage ICT as meaningful STEM pedagogical tools. Furthermore, the five contextual constructs that describe the educational institution level indicate how educators' use of ICT for teaching and learning is influenced by the social and organizational milieu in which they live and work. Therefore, educational leadership is critical in facilitating educators' technology change. Hence, education leaders can provide support and resources so educators can integrate ICT effectively into their STEM teaching.

The SITI instrument is designed as a self-assessment tool to guide professional learning. It becomes a complementary measurement in SPMa (Standard Pendidik MARA) system in section Standard Amalan 1 (SA1) that examines standard professionalism of TVETMARA educators. The system is assessed in January every year for the educators to reflect on their pedagogical practices. Hence, SITI can complement SA1 with the measurement of five contextual factors (ICT Selection, Organisation Support, Peer Collaboration, Pedagogical Practices and STEM teaching. These five contextual factors should first be addressed in preparing the ICT training professionals program. Moreover, the primary intended use of this instrument is complementary to SPMa, a MARA instrument in reflecting standard teaching

practices in the organization. The use of ICT has significantly been emphasized to educators in their teaching and learning activities. Therefore, SITI can become a reflection tool to assist educators in thinking about their teaching practices with ICT. Differs from existing instruments, SITI

6.4 Limitations

While this thesis makes a contribution to STEM Education research with ICT in TVET educational setting, there are several limitations that need to be identified.

First, the constraints in the sample size of the study. To conduct construct validation, it requires a large sample to provide stable and reliable estimates. Moreover, small samples can lead to poor model fit. In developing SITI, two sample size collections were collected to perform construct validation. Prior to exploratory factor analysis, there were 162 TVETMARA participants collected using convenience sampling. For confirmatory factor analysis, a different sample size was collected which involved 265 TVETMARA educators. Though measured value of KMO analysis which was 0.904 provided sample appropriateness to perform EFA, the ratio of 5 to 10 participants per item was recommended for good statistical estimation. Moreover, there might not adequately capture the variability in teaching practices using ICT in STEM teaching since the participants only came from technical and engineering background from TVETMARA. Hence, the findings and implications of the study are not ready to be generalized to other TVET providers.

Second, the analytical techniques used in the validating construct in SITI through confirmatory factor analysis. The study employed CB-SEM which used the fit indices such as Chi-square, RMSEA, CFI, and TLI. These fit indices can be sensitive to 265 sample size and

model misspecification. Moreover, the risk of overfitting the 5-factor model to the 265 sample might not imply that 5-factor model SITI is correct. It only suggests that the SITI instrument is not wrong in ways that are detectable by the fit indices, which can lead to over-reliance on these indices. Thus, conducting overfitting to SITI model reduces the generalizability of the findings.

The third concern about development and validation of SITI is regarding the two items that represent theme STEM Teaching. Furthermore, two items are unlikely to capture the full scope and complexity of STEM teaching. STEM teaching involves various elements, including integration of disciplines, hands-on activities, problem-solving, and use of technology which also related items from other constructs. Therefore, with only two items, there is a high risk that important aspects of STEM instruction are overlooked, leading to a construct that does not fully represent what it intends to measure.

6.5 Future Research

Based on the limitations identified in the study, several recommendations for future research are proposed to enhance the development and validation of the STEM ICT Teaching Inventory (SITI).

Since current study faced constraints related to the sample size, future research aims to increase the sample size using the recommended 5-10 participants to item to provide more stable and reliable validation of SITI. Besides that, expanding the sample by including TVET educators from a broader range of TVET providers (Vocational College, Polytechnic) and disciplines beyond technical and engineering backgrounds (IT, Design) could better capture activities of ICT teaching practices in STEM contexts and improve the generalizability of the findings. Besides that, researchers can also validate SITI across diverse educational contexts such as

different grade levels (secondary education) or geographic areas. This can help to confirm SITI' reliability across various education settings.

Second, the study utilized covariance-based structural equation modeling (CB-SEM) that is sensitive to sample size and model misspecification. CB-SEM requires relatively larger sample size. Due to its reliance on covariance matrices, a small sample size can cause unstable covariance matrices. Hence, the analysis result may lead to biasness or less reliable conclusions. Therefore, for future studies, researcher will employ an alternative method using partial least squares SEM (PLS-SEM) that offers more robust results with smaller or complex samples. PLS is a variance-based technique emphasizes prediction in estimating statistical models. This method is suitable for exploratory study and less restrictive for normal distribution data. Using PLS-SEM can improve the reliability and validity of SITI.

Additionally, to improve the overfitting issue in confirmatory analysis, the researcher will use a hold-out sample strategy to enhance the validity, reliability, and generalizability of the STEM ICT Teaching Inventory. In a hold-out sample, data are prepared in two or more subsets with one sub set for model training and another set for generalizability. Once the data from model training has been refined for validation and reliability testing, it can be performed on the hold-out sample.

One critical limitation of the current study was the use of only two items to represent the STEM instruction construct. Given the multifaceted nature of STEM teaching—encompassing interdisciplinary integration, hands-on activities, problem-solving, and technology use—two items are insufficient to capture the full complexity of this construct. Future research should focus on developing additional items that reflect a broader range of STEM teaching practices to

ensure a more comprehensive measurement. This expansion will help enhance the construct validity of SITI, ensuring that it accurately reflects the intended dimensions of STEM teaching.

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APPENDICES

Appendix A: Request for Permission to conduct Research (STEM ICT Teaching Inventory SITI)

Sent: Monday, 3 October, 2022 8:59 PM
To: Deputy Academic Directors IKM/KKTM and MJJI
Cc: Directors of IKM/KKTM and MJJI

Subject: MEMOHON KEBENARAN MENGEDARKAN INSTRUMEN KAJI SELIDIK INVENTORI STEM(ICT) TEACHING INVENTORY (KKTM/MJII)

Assalamualaikum wrt

Tuan,

Memohon Kebenaran Mengedarkan Instrumen Kaji selidik Inventori Pengajaran STEM (ICT) Di Kalangan Pendidik TVET MARA (Bidang Kejuruteraan)

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Saya adalah staf MARA yang sedang meneruskan pengajian kedoktoran falsafah dalam bidang Sains Pembelajaran di Fakulti Kognitif Sains dan Pembangunan Manusia, Universiti Malaysia Sarawak (UNIMAS) ingin memohon kebenaran untuk menjalankan penyelidikan pengintegrasian ICT dalam Pengajaran STEM di pusat-pusat TVET MARA. Penyelidikan ini adalah dalam bentuk kuantitatif (survei) dan melibatkan pendidik TVET MARA (Bidang Kejuruteraan) sebagai sampel kajian.

3. Bersama-sama ini saya sertakan surat pengesahan pelajar menjalankan penyelidikan dari pihak UNIMAS dan pautan Borang Soal selidik dalam versi Bahasa Melayu (https://bit.ly/ASTEMInventory) dan Bahasa Inggeris (https://bit.ly/aSTEMInventory) untuk rujukan tuan.

4. Saya amat berbesar hati sekiranya pihak Tuan memberikan kebenaran untuk menjalankan penyelidikan ini dan kerjasama untuk mengedarkan Inventori Pengajaran STEM (ICT). Ini disebabkan sebagai satu kepentingan untuk pihak organisasi dalam usaha ke arah pelaksanaan pendigitalan proses pengajaran dan pembelajaran di TVET MARA.

5. Sehubungan dengan itu, saya berharap pihak Tuan dapat mempertimbangkan dan meluluskan permohonan di atas. Kerjasama daripada pihak Tuan saya dahului dengan ucapan terima kasih.

Sekian, terima kasih.
Yang Benar,

[cid:6950b482-76d3-475e-a722-d443df6f7f88]
Fariedah Lal Chan
Pegawai Perkhidmatan Pendidikan
Institut Kemahiran MARA Kuching

DISCLAIMER
This e-mail (including any attachments) may contain confidential information and intended solely for the use of the individual or entity to whom they are addressed. If you are not the intended recipient, you are hereby notified that any dealing, review, distribution, printing, copying or use of this e-mails strictly prohibited. If you have received this e-mail in error, please notify the sender or MARA immediately and delete the original message. Opinions, conclusions and other information in this e-mail that do not relate to the official business of MARA and/or its subsidiaries shall be understood as neither given nor endorsed by MARA and/or its subsidiaries and neither MARA nor its subsidiaries accepts responsibility for the same. All liability arising from or in connection with this computer viruses and/or corrupted e-mails is excluded to the fullest extent permitted by law.

Appendix B: Sample of approval response

Received: from TYZPR04MB4126.apcprd04.prod.outlook.com (2603:1096:400:28::8)
by KL1PR04MB6781.apcprd04.prod.outlook.com with HTTPS; Tue, 4 Oct 2022
00:12:12 +0000
Received: from TYZPR04MB6134.apcprd04.prod.outlook.com (2603:1096:400:25c::5)
From: "Dr. Mahazani bin Ali" <Mahazaniali@mara.gov.my>
To: Fariedah Lal Chan <fariedah@mara.gov.my>
Subject: Re: MEMOHON KEBENARAN MENGEDARKAN INSTRUMEN KAJI SELIDIK INVENTORI
STEM(ICT) TEACHING INVENTORY (KKTM/MJII)

Waalaikumussalam

Berhubung dengan kebenaran mengedarkan instrumen Kaji selidik Inventori Pengajaran STEM (ICT) pihak kami tiada halangan untuk membenarkan soalan kajiselidik itu diedarkan kepada respondan.

Sekian terima kasih.

Appendix C: Request for approval for SITI distribution (by email)

Assalamualaikum wrt dan Salam sejahtera

Tuan,

Memohon Kebenaran Mengedarkan Instrumen Kaji selidik Inventori Pengajaran STEM (ICT) Di Kalangan Pendidik Teknikal TVET MARA

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Saya adalah staf MARA yang sedang meneruskan pengajian kedoktoran falsafah dalam bidang Sains Pembelajaran di Fakulti Kognitif Sains dan Pembangunan Manusia, Universiti Malaysia Sarawak (UNIMAS) ingin memohon kebenaran untuk menjalankan penyelidikan pengintegrasian ICT dalam Pengajaran STEM di pusat-pusat TVET MARA. Penyelidikan ini adalah dalam bentuk kuantitatif (survei) dan melibatkan pendidik teknikal TVET MARA sebagai sampel kajian.

3. Bersama-sama ini saya sertakan surat pengesahan pelajar menjalankan penyelidikan dari pihak UNIMAS dan pautan Borang Soal selidik dalam versi Bahasa Melayu (https://bit.ly/BSTEMInventory) dan Bahasa Inggeris (https://bit.ly/bSTEMInventory) untuk rujukan tuan.

4. Saya amat berbesar hati sekiranya pihak Tuan memberikan kebenaran untuk menjalankan penyelidikan ini dan kerjasama untuk mengedarkan Inventori Pengajaran STEM (ICT). Ini disebabkan sebagai satu kepentingan untuk pihak organisasi dalam usaha ke arah pelaksanaan pendigitalan proses pengajaran dan pembelajaran di TVET MARA.

5. Sehubungan dengan itu, saya berharap pihak Tuan dapat mempertimbangkan dan meluluskan permohonan di atas. Kerjasama daripada pihak Tuan saya dahului dengan ucapan terima kasih.

Sekian, terima kasih.

Yang benar,



Fariedah Lal Chan

Pegawai Perkhidmatan Pendidikan

Appendix D: Sample of response from IKM

```
      Received:        from        TYZPR04MB5878.apcprd04.prod.outlook.com
(2603:1096:400:1f2::9)
       by KL1PR04MB6781.apcprd04.prod.outlook.com with HTTPS; Thu, 20 Oct
2022
       02:33:49 +0000
      Received: from KL1PR0401MB5422.apcprd04.prod.outlook.com
       (2603:1096:820:87::12) by TYZPR04MB5878.apcprd04.prod.outlook.com
       (2603:1096:400:1f2::9) with Microsoft SMTP Server (version=TLS1_2,
       cipher=TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384)   id   15.20.5723.26;
Thu, 20 Oct
       2022 02:33:47 +0000
      From: [redacted]
      To: Fariedah Lal Chan <fariedah@mara.gov.my>
      Subject: Re: MEMOHON KEBENARAN MENGEDARKAN INSTRUMEN KAJIAN STEM
(ICT)
       TEACHING   INVENTORY   DI   KALANGAN   PENDIDIK   TVET   MARA   (BIDANG
KEJURUTERAAN)
```

Salam,
Saya dah highlight semula link tersebut untuk tindakan dalam group pensyarah. Rasanya tak perlu hardcopy.

Sekian, terima kasih.

"WAWASAN KEMAKMURAN BERSAMA 2030"
"BERKHIDMAT UNTUK NEGARA"
"LUAR BANDAR SEJAHTERA"

Saya yang menjalankan amanah,

Appendix E: Interview Protocol

KAJIAN:

PENGINTEGRASIAN TEKNOLOGI DALAM PENGAJARAN STEM DI TVET MARA

PROTOKOL TEMUBUAL

PENGENALAN DIRI

1. Bolehkah En/Pn memperkenalkan diri serta latarbelakang pendidikan En/Pn.
2. Apakah bidang En/Pn di dalam TVET MARA?
3. Apakah pengalaman professional anda di dalam industri?
4. Berapa lamakah En/Pn telah mengajar di pusat TVET MARA ini?

PROSES PdP DI TVET MARA

1. Apakah kaedah pengajaran yang digunakan di TVET MARA? (cth OBE, pbl, hands-on)
2. Apakah elemen-elemen yang ditekankan dalam pdp TVET MARA?
3. Adakah pengajaran STEM diperkasakan di TVET MARA?
4. Bolehkah anda ceritakan satu situasi di mana anda melaksanakan penggabungan jalinana konsep daripada disiplin atau bidang lain?

PENGALAMAN MENGGUNAKAN ICT DI DALAM PENGAJARAN STEM

1. Apakah alatan ICT yang digunakan di dalam pengajaran STEM anda?
2. Berapa lamakah anda sudah menggunakan alatan tersebut?
3. Apakah pendapat anda tentang penggunaan ICT di dalam pengajaran STEM?

KESAN PENGGUNAAN ICT DI DALAM PENGAJARAN STEM

1. Bagaimanakah alatan ICT tersebut memberi kesan positif kepada pengajaran STEM anda?
2. Bagaimanakah alatan ICT menukar amalan pedagogi anda?

MENGAPLIKASIKAN ICT DI DALAM PdP STEM MELALUI CONTOH SPESIFIK

1. Pilih satu sutb-topik/topik di dalam pengajaran STEM yang anda ingin ceritakan. Terangkan isi kandungan sub-topik/topik dan proses pengajaran STEM yang berlaku.
2. Terangkan objektif pembelajaran di dalam pengajaran STEM anda.
3. Ceritakan proses pengajaran STEM . Apakah alat ICT yang digunakan? Bagaimanakah alat ICT digunakan?
4. Terangkan sebarang maklumat organisasi (seperti akses kepada makmal komputer, bahan dan sumber yang ada) yang mempengaruhi perancangan dan pelaksanaan di dalam pengajaran STEM anda.
5. Bagaimanakah anda memilih alat ICT di dalam pengajaran STEM? Kenapakah alat ICT tersebut sesuai digunakan dalam pengajaran STEM anda?
6. Bagaimanakah objektif pengajaran, kaedah pengajaran dan penggunaan alat ICT memenuhi keperluan pengajaran dan pembelajaran?

Appendix F: Borang Maklumat Peserta

Participant Consent Form | Borang Maklumat Peserta

Assalammu'alaikum dan Salam Sejahtera

Tujuan Kajian

Saya dari Fakulti Sains Kognitif dan Pembangunan Manusia UNIMAS. Tujuan kajian ini adalah untuk mengkaji amalan pengintegrasian ICT di dalam pengajaran STEM di kalangan pendidik-pendidik MARA TVET. Saya ingin menjemput tuan/puan untuk turut serta berkongsi pendapat dan pengalaman berkenaan dengan amalan-amalan pengintegrasian ICT yang dilaksanakan oleh tuan/puan.

Peranan Anda

Jika tuan/puan bersetuju untuk turut serta, ini akan melibatkan satu sesi temubual yang akan mengambil masa selama 40 minit hingga 60 minit daripada masa tuan/puan.Walaubagaimanapun, tempoh masa adalah bergantung kepada tuan/puan dan kita boleh mengatur masa dan tempat perjumpaan mengikut kesesuaian dan keselesaan tuan/puan.

Persetujuan Penyertaan

Penyertaan tuan/puan adalah bersifat sukarela dan tuan/puan boleh menukar fikiran bila-bila masa jika hendak berbuat demikian. Saya akan merekod dan merakam sesi temubual dan saya akan hapuskan setelah selesai ditranskrip. Saya tidak akan nyatakan nama tuan/puan atau sebarang maklumat yang boleh menyebabkan tuan/puan dikenali dalam sebarang rekod dan maklumat yang akan kami gunakan.

Kerahsiaan

Segala maklumat tun/puan dijamin kerahsiaan dan hanya saya yang mengetahui penyertaan tuan/puan dalam kajian ini. Saya akan guna maklumat ini untuk tujun menulis hasil kajian, laporan dan pembentangan dalam persidangan. Saya akan pastikan sebarang maklumat yang digunakan tidak mengandungi nama tuan/puan dan akan dirahsiakan. Ini termasuklah petikan yang ditulis dalam artikel, bab buku, dan pembentangan.

Saya amat menghargai perkongsian tuan/puan, dan kajian ini adalah sebahagian daripada syarat keperluan pengajian saya. Sebarang maklumat lanjut berkaitan kajian ini boleh berhubung dengan saya Fariedah Lal Chan, no telefon 014 672 9004 atau email fariedah@mara.gov.my.

Terima kasih atas minat tuan/puan terhadap kajian ini. Saya mengalu-alukan kerjasama dan penyertaan tuan/puan.

Salam ikhlas,

Fariedah Lal Chan

Pelajar Doktor Falsafah (Sains Pembelajaran)

No. Matrik: 17010115

Appendix G: Borang Persetujuan Penyertaan

Borang Persetujuan Penyertaan

TAJUK KAJIAN :
ICT integration practices in STEM teaching of MARA TVET educators

Pastikan agar anda bersetuju dengan kenyataan di bawah sebelum ditemubual:

- Saya faham tujuan dan prosedur kajian
- Saya telah disediakan dengan borang maklumat peserta
- Saya faham yang penyertaan saya adalah sukarela
- Saya juga faham yang nama, alamat dan sebarang pengenalan diri tidak akan digunakan
- Saya faham yang jawapan dan tindakbalas saya akan dirahsiakan
- Saya bersetuju untuk turut serta dalam kajian ini
- Saya bersetuju yang temubual ini akan dirakamkan

Tandatangan : _____

Tarikh : _____

Appendix H: Sample Expert Review Form

BORANG SEMAKAN KESAHAN PAKAR

Assalammu'alaikum dan Salam Sejahtera

Tujuan Kajian
Saya dari Fakulti Sains Kognitif dan Pembangunan Manusia UNIMAS. Tujuan kajian ini adalah untuk mengkaji amalan pengintegrasian ICT di dalam pengajaran STEM di kalangan pendidik-pendidik MARA TVET.

Saya amat berbesar hati dan memohon agar panel pakar dapat menilai setiap item soalan bagi menjawab semua objektif yang telah digariskan oleh pengkaji berdasarkan tiga skala penilaian berdasarkan Lawshe (1975) iaitu;

- **Skala 1 : Essential (Sangat Penting)**
- **Skala 2 : Useful But Not Essential (Berguna Tetapi Tidak Penting)**
- **Skala 3 : Not Necessary (Tidak Perlu)**

Panel pakar dapat membuat pembetulan berdasarkan **konteks, kandungan ayat, laras bahasa** dan **jenis perkataan.**
Saya amat menghargai atas kesudian Prof/Dr/tuan/puan untuk menjadi panel pakar , dan kajian ini merupakan sebahagian daripada syarat keperluan pengajian saya. Sebarang maklumat lanjut berkaitan kajian ini boleh berhubung dengan saya Fariedah Lal Chan, no telefon 014 672 9004 atau email fariedah@mara.gov.my.

Terima kasih atas minat Prof/Dr/tuan/puan terhadap kajian ini. Saya mengalu-alukan kerjasama dan pendapat Prof/Dr/tuan/puan.

Salam ikhlas,

Fariedah Lal Chan

Pelajar Doktor Falsafah (Sains Pembelajaran)

No. Matrik: 17010115

No.	Perkara	Skala Persetujuan akar			Penerimaan/Komen	
		Penting *Essential*	Berguna Tapi Tidak Penting *Useful But Not Essential*	Tidak Penting *Not Necessary*	√ / X	Komen *Comment*
Maklumat Demografi : Latarbelakang Profesion Dan Pendidikan *Demographic information : Professional background and education – CONTENT KNOWLEDGE*						
1	Berapa lamakah En/Pn telah mengajar di MARA TVET? *How long have you been teaching in MARA TVET?*	√			√	Relevan
2	Berapa pusat MARA TVET telah En/Pn mengajar? *How many MARA TVET centers have you taught?*	√			√	Relevan utk mengetahui sejauh mana keterlibatan pengajar bersama MARA TVET.
3	Berapa lamakah En/Pn telah mengajar dekat (di) pusat terkini? *How long have you been teaching at the current center?*		√		X	Info yang redundant dgn item (1), dan kurang bermanfaat.
4	Apakah bidang pengkhususan En/Pn di dalam MARA TVET?) *What is your field specification in MARA TVET?*	√			√	Sesuai
Cadangan :						

Tiada						
No.	**Perkara**	**Skala Persetujuan Pakar**			**Penerimaan/Komen**	
		Penting *Essential*	Berguna Tapi Tidak Penting *Useful But Not Essential*	Tidak Penting *Not Necessary*	√ / X	Komen *Comment*
Pengajaran dan pembelajaran (pdp) proses di MARA TVET *Teaching and learning process in MARA TVET – PEDAGOGICAL KNOWLEDGE*						
1	Apakah kaedah pengajaran yang digunakan? *What is the teaching method used?*	√				
2	Apakah komponen pengajaran di dalam kursus di MARA TVET? *What are the teaching components in the courses in MARA TVET?*	√				
3	Adakah berlaku pengajaran melalui gabungan konsep dan merentasi kurikulum? *Do teaching through combination of concepts and across curriculum occur?*	√			√	Perlukan lebih penjelasan tentang makna merentasi kurikulum. Masih kabur.
4	Bolehkah En/Pn terangkan menggunakan contoh salah satu kursus yang diajar di mana ~~di mana~~ menggunakan gabungan disiplin/bidang lain? *Can you describe through one of the courses that you teach where you combine other disciplines/fields?*	√			√	Sangat sesuai jika responden mempunyai pengalaman 'cross-disciplinary'.

Cadangan : Tiada						
No.	**Perkara**	**Skala Persetujuan Pakar**			**Penerimaan/Komen**	
		Penting *Essential*	Berguna Tapi Tidak Penting *Useful But Not Essential*	Tidak Penting *Not Necessary*	√ / X	Komen *Comment*
Pengalaman dalam menggunakan alat ICT di dalam pengajaran STEM *Experiences in using ICT tools in your STEM teaching – TECHNOLOGY PEDAGOGICAL KNOWLEDGE*						
1	Apakah alat ICT yang digunakan dalam pengajaran STEM? *What are the ICT tools that you use in your STEM teaching?*	√			√	Sangat relevan.
2	Berapa lamakah En/Pn telah menggunakan alat ICT dalam pengajaran STEM? *How long have you been using ICT tools in your STEM teaching?*	√			√	Relevan
3	Apakah pendapat En/Pn berkenaan menggunakan alat ICT di dalam pengajaran STEM? *What is your opinion on the use of ICT tools in STEM teaching?*	√			√	Relevan
Cadangan: Perlu ditanya adakah tenaga pengajar ini mengalami kesukaran dalam usaha menggunakan alat ICT?						

Apakah usaha yang diambil untuk memperbaiki kefahaman dan juga '*efficiency*' utk menggunakan alat ICT dalam mengajar. Tempoh masa yang diambil untuk beradaptasi dengan perubahan sistem pengajaran/pembelajaran menggunakan teknologi ICT.

No.	**Perkara**	**Skala Persetujuan Pakar**			**Penerimaan/Komen**	
		Penting *Essential*	Berguna Tapi Tidak Penting *Useful But Not Essential*	Tidak Penting *Not Necessary*	√ / X	Komen *Comment*
Impak penggunaan alat ICT di dalam pengajaran STEM *Impact using ICT tools in STEM teaching – TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE*						
1	Bagaimanakah alat ICT memberi impak yang positif terhadap pengajaran anda? *How does the ICT tool give positive impact toward your teaching?*	√			√	Sangat relevan
2	Bagaimanakah alat ICT mempengaruhi cara anda mengajar? *How does the ICT tool influence the way you teach?*	√			√	Sangat relevan
3	Bagaimanakah alat ICT menukar amalan pedagogi anda? *How does the ICT tool change your pedagogical practices?*	√			√	Sangat relevan

Cadangan :

Perlu juga ditanya sekiranya ada kesukaran yang dialami sepanjang menggunakan alat ICT dalam pdp, seperti tiada internet, laptop yang

tidak effisien, dan sebagainya.
Bagaimana response dan kesediaan pelajar terhadap penggunakan alat ICT.

No.	Perkara	Skala Persetujuan Pakar			Penerimaan/Komen	
		Penting *Essential*	Berguna Tapi Tidak Penting *Useful But Not Essential*	Tidak Penting *Not Necessary*	√ / X	Komen *Comment*
Penerangan proses pengajaran STEM menggunakan alat ICT dengan menggunakaan contoh spesifik *STEM teaching process where applying ICT tools using specific example – TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE*						
1	Pilih satu sutb-topik/topik di dalam pengajaran yang anda ingin ceritakan. Terangkan isi kandungan sub-topik/topik dan proses pengajaran yang berlaku. *Choose one sub-topic/topic in your teaching that you would like to talk about. Explain the content of the sub-topic/topic and the teaching process that takes place.*	√				Relevan
2	Terangkan objektif pembelajaran di dalam pengajaran anda. *Explain the learning objectives in your teaching.*	√				Relevan
3	Terangkan latarbelakang pelajar (seperti semester dan keperluan khusus di dalam pengajaran). *Explain the students background (such as*		√			Kurang bermanfaat kerana secara general kita telahpun maklum

	semester and special needs in the teaching).					kajian ini utk pelajar MARA TVET, tiada perbezaan semester mana pelajar tersebut diajar.
4	Ceritakan proses pengajaran. Apakah alat ICT yang digunakan? Bagaimanakah alat ICT digunakan? *Tell me the teaching process. What is the ICT tool that is used? How is the ICT tool used?*	√				Relevan
5	Terangkan sebarang maklumat organisasi yang mempengaruhi perancangan dan pelaksanaan di dalam pengajaran anda. *Explain any organizational information that influence the planning or the implementation in your teaching.*	√				Berikan sedikit penjelasan, kerana sedikit kabur untuk makna maklumat organisasi.
6	Bagaimanakah anda memilih alat ICT di dalam pengajaran? Kenapakah alat ICT sesuai digunakan dalam pengajaran anda? *How do you choose the ICT tool for your teaching? Why does the ICT tool suit your teaching?*	√				Relevan
7	Bagaimanakah anda memilih alat ICT yang sesuai dengan kaedah pengajaran anda? Mengapakah alat ICT tersebut sesuai dengan kaedah pengajaran anda?	√				Relevan

	How do you choose ICT tool that suit your teaching strategy? Why does the ICT tool suit your teaching strategy?					
8	Bagaimanakah dan kenapakah objektif pengajaran, kaedah pengajaran dan penggunaan alat ICT memenuhi keperluan pengajaran dan pembelajaran? *How and why the learning objectives, teaching strategy and the application of ICT tools fulfill your teaching and learning needs?*	√				Relevan

Appendix J: Questionnaire

FACULTY OF COGNITIVE SCIENCE AND HUMAN DEVELOPMENT

RESEARCH TITLE:

ICT INTEGRATION PRACTICES IN STEM TEACHING AMONG TVET MARA EDUCATORS

Dear Participants,

You are invited to participate in the research of your ICT integration practices in STEM teaching. In this research, STEM teaching is defined as pedagogical practices in teaching Engineering/Technical subject with cross disciplines from Science, Mathematics and Technology in the context of real life or workforce problem. ICT integration refers to using of digital technologies in a positive manner that contribute to the enhancement of teaching and learning . Digital technologies in ICT includes both hardware and software (e.g. internet-based education, IoT, social media, cloud computing, computer programming, online learning, streaming media, CAD/CAM and Learning Management System. The duration to complete STEM (ICT) teaching Inventory is approximately 15 - 30 minutes. The data collected will be anonymous and solely assessed by the researcher herself. Information will be analysed without prejudice and be used for academic purposes only.

There are TWO parts in STEM (ICT) teaching Inventory:

PART A : DEMOGRAPHIC INFORMATION

PART B : STEM (ICT) Teaching INVENTORY

a. ICT SELECTION
b. PEDAGOGICAL PRACTICES
c. LESSON PREPARTION
d. PEER COLLABORATION
e. ORGANIZATION SUPPORT

Please answer ALL the items listed truthfully based on your own opinions. My deepest appreciation for your cooperation and your interest on my research. If you have any concerns or questions, please contact the researcher at +6014-6729004.

Thank you.

Sincerely,

Fariedah Lal Chan

Phd (Learning Science)

fariedahlalchan@gmail.com

TAJUK KAJIAN:

AMALAN PENGINTEGRASIAN ICT DALAM PENGAJARAN STEM DALAM KALANGAN PENDIDIK TVET MARA

Tuan/Puan yang dihormati,

Saya ingin menjemput tuan/puan untuk mengambil bahagian dalam kaji selidik berkenaan dengan amalan Pengintegrasian ICT dalam pengajaran STEM. Dalam kajian ini, Pengajaran STEM ditakrif sebagai amalan pedagogi dalam mengajar subjek Kejuruteraan/Teknikal dengan merentas disipilin Sains, Matematik dan Teknologi. Pengintegrasian ICT merujuk kepada penggunaan teknologi digital dalam keadaan positif yang menyumbangkan pemerkasaan proses pengajaran dan pembelajaran. Teknologi digital dalam ICT merangkumi hardware dan software (contoh internet-based education, IoT, social media, cloud computing, computer programming, online learning, streaming media, CAD/CAM and Learning Management System). Tuan/Puan hanya memerlukan 15-30 minit untuk melengkapkan STEM (ICT) Teaching Inventory. Data yang dikumpul adalah rahsia dan anonymous. Maklumat yang dikumpul akan dianalisa tanpa prejudis dan hanya akan digunakan untuk pelaporan akademik tesis ini sahaja. Soal selidik ini mengandungi DUA bahagian seperti berikut:

BAHAGIAN A : MAKLUMAT DEMOGRAFI

BAHAGIAN B : STEM (ICT) TEACHING INVENTORY

a. PEMILIHAN ICT
b. AMALAN PEDAGOGI
c. PERSEDIAAN PENGAJARAN
d. KOLABORASI RAKAN SEKERJA
e. SOKONGAN ORGANISASI

Sila jawab SEMUA item yang disenaraikan secara jujur berdasarkan kepercayaan serta pandangan tuan/puan sendiri. Ribuan terima kasih diucapkan atas kerjasama dan sokongan tuan/puan. Sekiranya tuan/puan mempunyai sebarang persoalan, boleh menghubungi saya di no hp +06146729004.

Salam ikhlas,



Fariedah Lal Chan
Pelajar Doktor Falsafah (Sains Pembelajaran)
fariedahlalchan@gmail.com

SECTION A : DEMOGRAPHIC INFORMATION

Instructions : Please fill in your information by marking (/) in the blank space provided and the answer in the appropriate space.

BAHAGIAN A: MAKLUMAT DEMOGRAFI

Arahan: Sila isi maklumat anda dengan menandai (／) dalam petak kosong yang disediakan dan tulis jawapan pada ruang yang berkenaan.

1. Gender (Jantina) : Lelaki ☐

   Perempuan ☐

2. Age (Umur)

   : kurang daripada 30 tahun ☐

   : antara 30 tahun dan 40 tahun ☐

   : antara 41 tahun dan 51 tahun ☐

   : lebih daripada 51 tahun ☐

3. TVET MARA Centre (Tempat bertugas)

   : IKM KOTA KINABALU

4. Duration of teaching at current TVET MARA Centre
   (Tempoh mengajar di Pusat TVET MARA terkini)

   : kurang daripada 5 tahun ☐

   5 hingga 10 tahun ☐

   11 hingga 15 tahun ☐

   16 hingga 20 tahun ☐

   Lebih daripada 20 tahun ☐

1. Highest Academic Qualification
(Kelulusan Akademik Tertinggi)

: CERTIFICATE/ SIJIL ☐

ADVANCED DIPLOMA/DIPLOMA ☐

BACHELOR DEGREE/IJAZAH SARJANA MUDA ☐

MASTER DEGREE/IJAZAH SARJANA ☐

DOCTORAL DEGREE/ PHD ☐

2. Pedagogy/VTO training status (Status latihan pedagogi/VTO)

: Telah menghadiri ☐

: Belum menghadiri ☐

3. Years of Teaching
(Pengalaman Mengajar)

:

: kurang daripada 5 tahun ☐

: 5 hingga 10 tahun ☐

: 11 hingga 15 tahun ☐

: 16 hingga 20 tahun ☐

: Lebih daripada 20 tahun ☐

4. Years of using ICT to teach
(Pengalaman Mengajar menggunakan ICT)

: kurang daripada 5 tahun ☐

: 5 hingga 10 tahun ☐

: 11 hingga 15 tahun ☐

: 16 hingga 20 tahun ☐

: Lebih daripada 20 tahun ☐

5. Experience working in industry (if applicable)
(Pengalaman bekerja dengan perindustrian (sekiranya ada)

: tiada ☐

: kurang daripada 5 tahun ☐

: 5 hingga 10 tahun ☐

: 11 hingga 15 tahun ☐

: 16 hingga 20 tahun ☐

: Lebih daripada 20 tahun ☐

6. Expert field in TVET MARA
(Bidang Kepakaran dalam TVET MARA)

_____

SECTION B : STEM (ICT) TEACHING INVENTORY

The question below contains a list of relevant statements on ICT Integration Practices in STEM Teaching among TVET MARA lecturers.

Guidelines: Please read the item carefully and circle your level of agreement based on the statement provided.

BAHAGIAN B: INVENTORI PENGAJARAN STEM (ICT)

Soalan di bawah mengandungi senarai kenyataan yang berkaitan tentang Amalan Pengintegrasian ICT Dalam Pengajaran STEM / *ICT Integration Practices in STEM Teaching* dalam kalangan pensyarah TVET MARA .

Panduan: Sila baca item dengan teliti dan bulatkan tahap persetujuan anda berdasarkan pernyataan yang diberikan.

Strongly disagree *Sangat tidak setuju*	Disagree *Tidak setuju*	Somewhat disagree *Kadang-kadang tidak setuju*	Neutral *Natural*	Somewhat agree *Kadang-kadang setuju*	Agree *Setuju*	Strongly agree *Sangat setuju*
1	2	3	4	5	6	7

A) ICT SELECTION / *PEMILIHAN ICT BERDASARKAN KEPADA KEPERLUAN KURIKULUM TVET DAN KAEDAH PENGAJARAN* This section refers to ICT selection based on TVET MARA curriculum goals and teaching method. *Bahagian ini merujuk kepada pemilihan ICT yang digunakan berdasarkan kepada keperluan kurikulum TVET MARA dan kaedah pengajaran anda.*	Strongly disagree *Sangat tidak setuju* → Strongly agree *Sangat setuju* 1 2 3 4 5 6 7
1. I select ICT which aligns with my learning outcomes. *Saya memilih ICT yang selari dengan hasil pembelajaran*.	1 2 3 4 5 6 7
2. I select ICT which aligns with my teaching methods in Theory class. *Saya memilih ICT yang selari dengan kaedah pengajaran untuk kelas Teori.*	1 2 3 4 5 6 7
3. I select ICT which aligns with my teaching methods in Practical class.	1 2 3 4 5 6 7

Saya memilih ICT yang selari dengan kaedah pengajaran untuk kelas Amali.	
4. I select ICT which aligns with my teaching method (demonstration). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk demonstrasi.*	1 2 3 4 5 6 7
5. I select ICT which aligns with my teaching method for hands-on. *Saya memilih ICT yang selari dengan kaedah pengajaran untuk 'hands-on'.*	1 2 3 4 5 6 7
6. I select ICT which aligns with my teaching method (problem-based learning). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk 'problem-based learning'.*	1 2 3 4 5 6 7
7. I select ICT which aligns with my teaching method (project-based learning). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk 'project- based learning'.*	1 2 3 4 5 6 7
8. I select ICT which aligns with my teaching method (inquiry-based learning). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk 'inquiry- based learning'.*	1 2 3 4 5 6 7
9. I select ICT which aligns with my teaching method (group learning). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk pembelajaran berkumpulan.*	1 2 3 4 5 6 7
10. I select ICT which aligns with teaching method (case study). *Saya memilih ICT yang selari dengan kaedah pengajaran untuk kajian lapangan.*	1 2 3 4 5 6 7
B) PEDAGOGICAL PRACTICES /*AMALAN PEDAGOGI* This section refers to ICT usage in pedagogical practices of STEM teaching that includes integration and cross disciplines as well as used of ICT in class management to support learning effectively. *Bahagian ini merujuk kepada penggunaan ICT dalam amalan*	Strongly disagree *Sangat tidak setuju* Strongly agree *Sangat setuju*

pedagogi pengajaran STEM yang merangkumi gabung jalinan dan merentasi disiplin serta penggunaan ICT dalam pengurusan kelas yang menyokong pembelajaran yang efektif.	1 2 3 4 5 6 7
11. I use videos from internet to show real life/ workplace situations. *Saya menggunakan video daripada internet untuk menunjukkan situasi sebenar kehidupan/tempat bekerja.*	1 2 3 4 5 6 7
12. I use images from internet to show real life/workplace situations. *Saya menggunakan imej daripada internet untuk menunjukkan situasi sebenar kehidupan/tempat bekerja.*	1 2 3 4 5 6 7
13. I use computer aided design to show real life/workplace situations. *Saya menggunakan 'computer aided design' untuk menunjukkan situasi sebenar kehidupan/tempat bekerja.*	1 2 3 4 5 6 7
14. I use ICT to record my classes (theory/practical). *Saya menggunakan ICT untuk membuat rakaman ketika kelas (teori/amali).*	1 2 3 4 5 6 7
15. I use ICT to record my students' attendance. *Saya menggunakan ICT untuk mengambil kehadiran pelajar.*	1 2 3 4 5 6 7
16. I use ICT for submission of my students' work. *Saya menggunakan ICT untuk pelajar menghantar Latihan/penilaian.*	1 2 3 4 5 6 7
17. I use ICT to differentiate my students' learning styles. *Saya menggunakan ICT untuk membezakan gaya pembelajaran pelajar.*	1 2 3 4 5 6 7
18. I use ICT based task for my students' assessment. *Saya menggunakan 'ICT based task' untuk menilai pelajar.*	1 2 3 4 5 6 7
19. I use ICT to conduct my students' evaluation. (eg Microsoft/Google form/quizizz/liveworksheet). *Saya menggunakan ICT untuk penilaian pelajar (seperti Microsoft /Google form/quizizz/liveworksheet).*	1 2 3 4 5 6 7

C) LESSON PREPARATION / *PERSEDIAAN SESI PdP*. This section refers to TVET MARA Educators' preparation of digital teaching and learning materials based on course structures, students' readiness with ICT, teaching method used and ICT facilities provided by organisation. *Bahagian ini merujuk kepada persediaan Pendidik TVET MARA dalam menyediakan bahan pdp secara digital berdasarkan struktur kursus,kesediaan ICT pelajar, kaedah pengajaran yang digunakan serta kesediaan pasarana ICT dalam organisasi.*	Strongly disagree *Sangat tidak setuju* → Strongly agree *Sangat setuju* 1 2 3 4 5 6 7
20. I design my daily lesson plan that integrates ICT in STEM teaching. *Saya menghasilkan rancangan pengajaran harian yang mengintergrasikan ICT dalam pengajaran STEM.*	1 2 3 4 5 6 7
21. I develop my own video for STEM teaching. *Saya menghasilkan video untuk pengajaran STEM.*	1 2 3 4 5 6 7
22. I design my PowerPoint slides based on my learning outcomes in STEM teaching. *Saya menghasilkan slaid PowerPoint berdasarkan hasil pembelajaran dalam pengajaran STEM.*	1 2 3 4 5 6 7
23. I design images using ICT to demonstrate complex ideas in STEM teaching. *Saya menghasilkan imej menggunakan ICT untuk demonstrasi idea yang sukar dalam pengajaran STEM.*	1 2 3 4 5 6 7
24. I design images using ICT to visualize learning contents that difficult to observe explicitly in STEM teaching. *Saya menghasilkan imej menggunakan ICT untuk menggambarkan kandungan pembelajaran yang sukar difahami dalam pengajaran STEM.*	1 2 3 4 5 6 7
25. I install computer design software before STEM teaching. *Saya memasang perisian 'computer design software' sebelum pembelajaran STEM*	1 2 3 4 5 6 7
26. I upload my teaching digital materials before STEM teaching. *Saya memuat naik bahan pengajaran digital sebelum pengajaran STEM.*	1 2 3 4 5 6 7
27. I share website link with students before STEM teaching. *Saya memberikan link website kepada pelajar sebelum pengajaran STEM.*	1 2 3 4 5 6 7

D) PEER COLLABORATION/ *KOLABORASI ANTARA PEER.* This section refers to collaboration with peers of TVET MARA Educators in developing digital teaching materials and collaboration with students and technical group to assist in troubleshooting. *Bahagian ini merujuk kepada kolaborasi antara rakan pensyarah TVET MARA dalam membangunkan bahan pengajaran digital, kolaborasi dengan pelajar dan kumpulan teknikal dalam membantu masalah 'troubleshooting'.*	Strongly disagree *Sangat tidak setuju* Strongly agree *Sangat setuju*  1 2 3 4 5 6 7
28. I develop videos for hands-on class with TVET MARA peers. *Saya menghasilkan video untuk kelas 'hands-on' bersama-sama rakan pensyarah TVET MARA.*	1 2 3 4 5 6 7
29. I develop PowerPoint slides for STEM teaching with TVET MARA peers. S*aya menghasilkan slaid PowerPoint untuk pengajaran STEM bersama-sama rakan pensyarah TVET MARA.*	1 2 3 4 5 6 7
30. I develop pictures and images for STEM teaching with TVET MARA peers. *Saya menghasilkan gambar dan imej untuk pengajaran STEM bersama-sama rakan pensyarah TVET MARA.*	1 2 3 4 5 6 7
31. I share STEM teaching digital materials with TVET MARA peers. *Saya berkongsi bahan pengajaran STEM digital bersama-sama rakan pensyarah TVET MARA.*	1 2 3 4 5 6 7
32. I share STEM teaching digital assessment materials with TVET MARA peers. *Saya berkongsi bahan untuk penilaian pengajaran STEM bersama-sama rakan pensyarah TVET MARA.*	1 2 3 4 5 6 7
33. I collaborate with students' apprentice to assist students to solve technical problem (eg installing software, wifi). *Saya berkolaborasi dengan pelatih pelajar untuk membantu pelajar lain menyelesaikan masalah teknikal (cth memasang perisian, wifi).*	1 2 3 4 5 6 7
34. I collaborate with peers from technical group to assist with technical problems (eg installing software, wifi).	1 2 3 4 5 6 7

Saya berkolaborasi dengan rakan kumpulan teknikal untuk menyelesaikan masalah teknikal (cth: memasang perisian, wifi).	
E) ORGANISATION SUPPORT / *SOKONGAN ORGANISASI.* This section refers to support given by organisation in providing teaching and learning facilities of ICT that are conducive and ICT pedagogical trainings. *Bahagian ini merujuk kepada sokongan yang diberi oleh organisasi dalam menyediakan pasarana pdp ICT yang kondusif dan latihan pedagogi ICT.*	Strongly disagree *Sangat tidak setuju* Strongly agree *Sangat setuju*  1 2 3 4 5 6 7
35. My organisation provides ICT based on TVET MARA course syllabus needs. *Organisasi saya menyediakan ICT berdasarkan keperluan silibus kursus TVET MARA.*	1 2 3 4 5 6 7
36. My organisation provides ICT based on technical field needs. *Organisasi saya menyediakan ICT berdasarkan keperluan bidang teknikal.*	1 2 3 4 5 6 7
37. My organisation provides ICT which aligns with industry needs. *Organisasi saya menyediakan ICT selari dengan keperluan industri.*	1 2 3 4 5 6 7
38. My organisation provides sufficient lab facilities. *Organisasi saya menyediakan keperluan makmal yang secukupnya.*	1 2 3 4 5 6 7
39. My organisation provides digital teaching materials (eg e-module) *Organisasi saya menyediakan bahan pengajaran digital (cth e-modul).*	1 2 3 4 5 6 7
40. My organisation provides ICT training to enhance ICT knowledge. *Organisasi saya menyediakan Latihan ICT untuk meningkatkan pengetahuan ICT.*	1 2 3 4 5 6 7
41. My organisation provides ICT training to enhance content knowledge. *Organisasi saya menyediakan latihan ICT untuk meningkatkan kepakaran dalam bidang ICT.*	1 2 3 4 5 6 7

42. My organisation provides ICT training to enhance pedagogical knowledge. *Organisasi saya menyediakan latihan ICT untuk meningkatkan pengetahuan pedagogi*.	1 2 3 4 5 6 7

Appendix K: TPACK OBSERVATION CHECKLIST



CLASS OBSERVATION PROTOCOL – FOR TVETMARA EDUCATORS

TVETMARA Educator's name :

Date and time :

Programme observed :

Course observerd :

Number of students in class :

Ttitle/topic being taught :

GENERAL OBSERVATION

1. What teaching aided tools (ABM) were used during the lesson?
2. What ICT tools were used during the lesson? What are the role of ICT tools in the lesson? How ICT tools were apply in the lesson?
3. What instructional strategies were used during the lesson?
4. Describe the activities that took place during the lesson.

TECHNOLOGY KNOWLEDGE

1. Any essential ICT tools required for the lesson
2. TVETMARA educator's familiarity and abilities to employ ICT tools for the lesson
3. Demonstrate any technical abilities to handle ICT tools for the lesson

CONTENT KNOWLEDGE

1. Exhibits mastery in subject matter
2. Exhibits industry relation in subject matter
3. Exhibits cross discipline/curriculum
4. Presents relevant and accurate facts of the topic taught
5. Provides variety of references and examples for students to gain knowledge in topic taught

PEDAGOGICAL KNOWLEDGE

1. Exhibits essential pedagogical approaches such as student-centered and problem based learning during lesson preparation and presentation
2. Demonstrates understanding of different styles of students learning
3. Structures the lesson to promote student learning

PEDAGOGICAL CONTENT KNOWLEDGE

1. The use of pedagogy to shape the content of topic taught
2. The content of topic shapes the use of pedagogy
3. Exhibits the used of pedagogy to assist students in their learning

TECHNOLOGICAL CONTENT KNOWLEDGE

1. The use of ICT tools to shape the content of topic taught
2. The content of topic shapes the use of ICT tools
3. Exhibits the used of ICT tools to assist students in their learning

TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE

1. The used of ICT tools to shape the pedagogical approaches
2. The pedagogical approaches shapes the choice of ICT tools used

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK)

1. The combination of content, ICT tools and STEM pedagogical approaches suit appropriately the topic taught

CONTEXTUAL KNOWLEDGE

1. The use of ICT tools based on the assessibility provided by TVETMARA institutions
2. The pedagogical approaches aligned with content in TVETMARA curriculum

Appendix L : TPACK Lesson Plan Analysis

Lesson Plan 1 Electric Circuit Theory 2 (DEV 21053)

Based on the 'Technology Integration Assessment Rubric', the lesson plan for 'Electric Circuit Theory 2 (DEV 21053)' analysed under the following criteria :

1. 'Curriculum Goals & Technologies'

- 'Analysis': The technologies selected, such as 'PowerPoint slides, LCD projectors', and 'videos', are strongly aligned with the curriculum goals of TVETMARA. The primary objective of the lesson is to teach 'first-order circuits, energy storage elements, and differential equations', and the multimedia tools selected support this by visually and practically engaging students in these complex concepts. For example, videos were used to explain transient states and the properties of circuits, while PowerPoint slides aided in visualizing key equations and relationships. This strong alignment ensures that technology is being used effectively to meet the lesson's objectives and the TVETMARA curriculum's technical focus.

2. 'Instructional Strategies & Technologies'

- 'Analysis': The instructional strategies employed in this lesson plan are well-supported by the technology used. The 'development phase' of the lesson integrates ICT tools like 'PowerPoint' and 'videos' to explain complex theoretical content, ensuring that students engage with the material through 'multiple modalities' (visual, auditory, and kinesthetic). The use of a 'problem-based learning (PBL)' approach, supported by 'exercise sheets' and 'real-time problem-solving', emphasizes active student engagement. The ICT tools complement these instructional strategies, ensuring that students are able to transition from theoretical learning to practical application with ease.

3. ‘Technology Selection(s)’

- ‘Analysis’: The technologies chosen for this lesson—’PowerPoint slides, videos, and an LCD projector’—are appropriate for the instructional goals and support the learning of complex engineering concepts. However, while these technologies adequately meet the curriculum needs, they do not push the boundaries of exemplary technology integration. More advanced tools, such as ‘simulation software’ or ‘interactive circuit-building platforms’, could have further enhanced the practical understanding of electrical circuits and differential equations. As such, while the technology selection is suitable, it could be further enhanced by incorporating tools that allow for deeper interactivity and student experimentation.

4. ‘“Fit” (Content, Pedagogy, and Technology)’

- ‘Analysis’: The integration of content, pedagogy, and technology in this lesson plan is well-rounded and cohesive. The use of ‘videos and slides’ to explain abstract concepts such as ‘first-order transient analysis’ aligns well with the pedagogical approach of ‘scaffolding’—gradually moving from basic concepts to more complex ones. The combination of ‘visual aids’ and ‘active student engagement’ (through real-time questions and problem-solving) ensures that the lesson’s instructional strategies and content are delivered effectively through the selected technologies. Furthermore, the use of ‘formative assessment’ (e.g., quizzes and peer collaboration) further reinforces this alignment, ensuring that the technology supports both teaching and learning in a meaningful way.

The lesson plan for ‘Electric Circuit Theory 2 (DEV 21053)’ demonstrates a strong alignment between curriculum goals and the technologies used. The instructional strategies are well-supported by the technology, and there is a clear fit between the content,

pedagogy, and selected ICT tools. Although the technologies selected are appropriate and serve the purpose well, there is potential for enhancing student engagement and understanding through more interactive or simulation-based tools. Nevertheless, the current integration of technology optimally supports the learning objectives, making it an effective and well-structured lesson.

Lesson Plan 2 CAD for Engineering 1 (GMD10024)

Based on the ‘Technology Integration Assessment Rubric’, the lesson plan for ‘CAD for Engineering 1 (GMD10024)’ analyzed using four key criteria: ‘

1. ‘Curriculum Goals & Technologies’

- ‘Analysis’: The technologies selected for the lesson plan, specifically ‘AutoCAD 2021 software, Microsoft Teams, and PowerPoint’, are strongly aligned with the curriculum goals of developing industry-relevant competencies in ‘computer-aided design (CAD)’. The lesson focuses on teaching students about dimensioning, which is a core aspect of CAD, and the chosen technologies directly support this. ‘AutoCAD 2021’, as the primary tool, is essential for students to practice dimensioning in a real-world software environment. Additionally, ‘Microsoft Teams’ serves as the platform for instructional delivery, ensuring that the lesson adheres to the online learning format while maintaining its technical focus.

2. ‘Instructional Strategies & Technologies’

- ‘Analysis’: The instructional strategies employed in the lesson plan are well-supported by the use of ‘AutoCAD software’ and ‘Microsoft Teams’. The lesson includes both instructional development and hands-on practical application, using ‘AutoCAD’ to allow students to apply what they have learned in real time. The ‘"Sharing" method’, where students receive personalized guidance while practicing techniques on their individual laptops, ensures that technology facilitates direct application of knowledge. The integration

of ‘visual aids’ (e.g., PowerPoint presentations) also reinforces understanding by visually demonstrating dimensioning techniques, ensuring that students can both see and practice these concepts.

3. ‘Technology Selection(s)’

- ‘Analysis’: The selection of ‘AutoCAD 2021’ as the core technology is exemplary, given the curriculum goals and instructional strategies. AutoCAD is the industry standard for CAD, and its use in the lesson ensures that students are working with the most relevant tools for the field. In addition, ‘Microsoft Teams’ is used effectively to facilitate both the delivery of content and real-time interaction between the instructor and students. The ‘Quizizz platform’ for formative assessment is another well-chosen technology, ensuring that the evaluation process is interactive and provides immediate feedback. The combination of these technologies ensures that students are engaging with tools that mirror real-world CAD applications, providing them with practical skills.

4. ‘“Fit” (Content, Pedagogy, and Technology)’

- ‘Analysis’: There is a strong fit between the content, pedagogy, and technology in this lesson plan. The content—dimensioning in ‘AutoCAD’—is delivered through ‘hands-on learning’ using the AutoCAD software, allowing students to directly apply the concepts being taught. The pedagogical approach of ‘student-centered learning’, where students receive personalized guidance while working on their own CAD drawings, is well-supported by the use of AutoCAD and ‘Microsoft Teams’. The ‘formative assessment’ using Quizizz further strengthens this fit, providing an interactive way to gauge student understanding. The overall use of technology seamlessly integrates with the instructional strategies and content, ensuring that students not only understand the theory behind dimensioning but can also apply it effectively.

The lesson plan for ‘CAD for Engineering 1 (GMD10024)’ demonstrates exemplary use of technology to support curriculum goals and instructional strategies. The selection of ‘AutoCAD 2021, Microsoft Teams’, and ‘Quizizz’ is highly appropriate, and these tools are used effectively to facilitate both theoretical learning and hands-on application. The fit between content, pedagogy, and technology is strong, ensuring that students are engaged in a meaningful and practical learning experience. This lesson plan excels in integrating technology to enhance both teaching and learning, making it a model example of technology-supported vocational education.

Lesson Plan 3 Electricity Supply Act & Regulations 1 (CEV61022)

Based on the Technology Integration Assessment Rubric, the lesson plan for Electricity Supply Act & Regulations 1 (CEV61022) analyzed using four key criteria:

1. Curriculum Goals & Technologies

- Analysis: The technologies selected for the lesson plan, including ‘Microsoft Teams’ and ‘information sheets’, are aligned with the curriculum goals. The lesson focuses on teaching students about key regulations and responsibilities outlined in the ‘Electricity Supply Act’. The selected technology—Microsoft Teams—is an effective platform for delivering content in an online learning environment, ensuring that students can participate in a remote setting. The use of ‘information sheets’ and direct reference to the ‘Electricity Supply Act 447’ further supports the goal of ensuring that students understand legal requirements in their field. However, while the technology is appropriately aligned, it does not provide extensive engagement with the content beyond a basic level of online interaction.

2. ‘Instructional Strategies & Technologies’

- ‘Analysis’: The instructional strategies employed in the lesson plan are supported by the technology used. The lesson is largely based on ‘lecturing, question-and-answer sessions’, and

‘interactive discussions’. The use of ‘Microsoft Teams’ facilitates real-time interaction between the instructor and students, enabling active participation in the discussion of legal regulations. However, the integration of technology could be enhanced with additional tools that promote more ‘active engagement’ and ‘student interaction’, such as legal case simulations or interactive quizzes that test students’ understanding of regulatory frameworks. The existing strategy supports participation, but there is room for further enhancement through more engaging digital tools.

3. ‘Technology Selection(s)’

- ‘Analysis’: While ‘Microsoft Teams’ and ‘information sheets’ are appropriate for delivering the lesson content, the selection of technologies could be improved to better meet the needs of this subject. For example, more interactive technologies such as ‘polling tools’ or ‘case-study simulations’ could have been integrated to help students apply legal knowledge in a more practical and engaging way. The reliance on Microsoft Teams for content delivery works well for remote learning but lacks the ‘interactivity’ or ‘hands-on components’ that could deepen students' understanding of complex regulations and their practical application. While the technology serves its purpose, it does not maximize the potential for engagement or provide the depth of interactivity that could make the content more relatable and practical for students.

4. ‘“Fit” (Content, Pedagogy, and Technology)’

- ‘Analysis’: The content, pedagogy, and technology used in the lesson plan generally fit together, but there is some room for improvement. The content—focused on legal regulations—aligns with the ‘pedagogical approach’ of discussing regulations and engaging students in questioning sessions. The use of ‘Microsoft Teams’ allows the instructor to effectively lead discussions and field student questions in real-time, ensuring that the learning remains interactive. However, the overall integration of technology lacks depth. The lesson could benefit from

additional tools that allow students to ‘apply legal concepts’ more practically, such as role-playing legal scenarios or working with simulation software to understand how regulations are enforced in real-world settings. While the current fit is functional, adding more interactive technologies could strengthen the lesson’s alignment with the pedagogical goals of ‘practical application’.

The lesson plan for ‘Electricity Supply Act & Regulations 1 (CEV61022)’ is well-aligned with the curriculum goals and supported by appropriate technology, but it could benefit from further enhancements. The instructional strategies are effectively supported by ‘Microsoft Teams’, ensuring students can engage in discussions and Q&A sessions. However, the technology selected is basic and could be improved with more interactive or practical tools that promote deeper student engagement. While the ‘content, pedagogy, and technology’ fit together, the integration is somewhat limited, and more advanced tools could help students better apply their knowledge of legal regulations. Overall, the lesson is functional and meets the minimum requirements for technology integration, but there is room for growth in terms of enhancing student interaction and application of knowledge.

Lesson Plan 4 Engineering Materials (NYV 3053)

Based on the ‘Technology Integration Assessment Rubric’, the lesson plan for ‘Engineering Materials (NYV 3053)’ analyzed using the four key criteria:

1. ‘Curriculum Goals & Technologies’

- ‘Analysis’: The technologies selected, such as ‘Microsoft Teams, PowerPoint presentations, videos’, and ‘WhatsApp group notes’, are strongly aligned with the curriculum goals of teaching students the fundamentals of ‘structure, properties, and classification of materials’. The content in this course is critical for understanding how materials behave in engineering applications, and the chosen technologies support this goal effectively. By integrating ‘videos’ to explain atomic structures and bonding, the lesson

makes abstract concepts more accessible and helps students relate these ideas to real-world engineering scenarios. Additionally, the use of multimedia presentations ensures that the technical content is delivered in a clear and engaging manner, directly supporting the learning objectives.

2. ‘Instructional Strategies & Technologies’

- ‘Analysis’: The instructional strategies used in this lesson plan are optimally supported by the chosen technologies. ‘Microsoft Teams’ allows the instructor to lead real-time discussions and interact with students in a virtual classroom environment, fostering student engagement. The ‘videos’ and ‘PowerPoint presentations’ complement the direct instruction by offering visual representations of complex engineering concepts like atomic bonds and material properties. This integration supports the ‘scaffolding strategy’, where students first gain a theoretical understanding and then build on that knowledge through examples and multimedia. The inclusion of ‘WhatsApp group notes’ further ensures that students have access to key information, reinforcing their learning outside of the classroom. The combination of these technologies provides a well-rounded learning experience that caters to different learning styles.

3. ‘Technology Selection(s)’

- ‘Analysis’: The technologies selected for this lesson—’Microsoft Teams, videos, PowerPoint presentations, and WhatsApp’—are appropriate for the instructional goals but not exemplary. While these tools provide a strong foundation for delivering content and facilitating student engagement, there is room for improvement. For instance, using ‘simulation tools’ or ‘virtual lab environments’ could further enhance the hands-on learning experience. The course content focuses heavily on the practical application of material properties, and interactive tools or ‘virtual labs’ could allow students to

experiment with material behavior in a more engaging way. While the current selection of technology is sufficient, incorporating more advanced tools would elevate the lesson's capacity to promote practical learning.

4. '"Fit" (Content, Pedagogy, and Technology)'

- 'Analysis': The integration of content, pedagogy, and technology in this lesson plan demonstrates a strong fit. The content—focused on the 'structure and properties of materials'—is well-supported by the pedagogical approach of 'multimedia-supported direct instruction' followed by interactive Q&A and group discussions. The use of 'videos' to explain complex topics such as 'atomic bonds' and 'material properties' fits seamlessly with the instructional strategy of using visual aids to enhance understanding. Furthermore, 'Microsoft Teams' provides a platform for interactive discussions, ensuring that the content is not only delivered but also actively engaged with by students. The overall design ensures that technology is used purposefully to reinforce both the theoretical and practical aspects of the course.

The lesson plan for 'Engineering Materials (NYV 3053)' demonstrates a strong alignment between curriculum goals, instructional strategies, and technology use. The technologies selected effectively support the content and pedagogical strategies, providing an engaging and interactive learning environment. While the current technology choices are appropriate and well-integrated, incorporating more 'interactive tools or simulations' could enhance the practical application of the material. Overall, the lesson shows a well-thought-out approach to integrating technology into teaching, ensuring that students gain a deep understanding of the course content while being engaged in meaningful learning experiences.

Appendix M : Quirkos Output

Quirkos

Quirkos Report

This report was generated by Fariedah LC on Fri Mar 18 2022 22:10:14 GMT+0800 (Malay Peninsula Standard Time) for the following file: C:/Users/Lenovo/Documents/Gamification/Full proposed work/Working article/QUALITATIVE DATA/DATA ANALYSIS/Quirkos Analysis/Interview.qrk.

Quirks Summary

Quirk Title		Description	Author	Date	Total Codes
STEM knowledge		Teachers content knowledge	Fariedah LC	Invalid Date	33
Curriculum goals and technology		Using ICT in instructional plan	Fariedah LC	Invalid Date	34
Lesson preparation			Fariedah LC	Invalid Date	19
Assessment			Fariedah LC	Invalid Date	26
Teaching strategies			Fariedah LC	Invalid Date	59
Class management			Fariedah LC	Invalid Date	46
Troubleshooting			Fariedah LC	Invalid Date	4
technology selection			Fariedah LC	Invalid Date	77
organization support			Fariedah LC	Invalid Date	36
Content Teaching strategy ICT fit			Fariedah LC	Invalid Date	17
Collaboration		Peer and students to support the use of ICT	Fariedah LC	Invalid Date	20
TVET curriculum			Fariedah LC	Invalid Date	14
Students' background			Fariedah LC	Invalid Date	20
STEM teaching			Fariedah LC	Invalid Date	50

online teaching			Fariedah LC	Invalid Date	42
develop ICT skill			Fariedah LC	Invalid Date	25
Constraint in using ICT			Fariedah LC	Invalid Date	16
Pedagogy training			Fariedah LC	Invalid Date	9
Pandemic era			Fariedah LC	Invalid Date	7
ICT training			Fariedah LC	Invalid Date	14
TOTAL NUMBER OF CODES	568				
TOTAL NUMBER OF QUIRKS	20				

SAMPLE Text Sorted by Theme

STEM knowledge

mengambil bidang teknikal iaitu di pusat pendidkan institute kemahiran mara Tan Sri Yahya Ahmad, Pekan..

Source: *X1*

sijil teknologi automotive

Source: *X1*

bidang diploma air conditioning Baikpulih Penyejukbekuan Refrigeration

Source: *X1*

Factory Maintenance

Source: *X1*

kerja2 yg sy lakukan ialah sy mengawal selia berkaitan dgn bidang MME iaitu mechanical dan electrical ..sy baikpulih bumbung..repairing electrical

Source: *X1*

pengajar dalam bidang elektrikal . Di bawah jabatan elektrikal IKM Kuching

Source: X2

belajar ke IKM Kuching selama 2 tahun dalam bidang Elektrikal

Source: X2

diploma pergi ke British Malaysia Institute dari tahun 2000 sehingga 2001, 2

tahun.

Source: X2

Diploma Electrical and Electronic Engineering, bawah Higher National Diploma in Electrical and Electronic.

Source: X2

1 tahun lebih sikit. Dan balik baru bekerja di area Kuching (13:42)..dalam bidang industri dan masih dalam bidang yang sama iaitu dalam bidang elektrikal

Source: X2

70% adalah wiring dan 30% adalah bahagian mekanikal macam lebih ke motor mekanikal ...gabungan elektrikal dan mekanikal.

Source: X2

sains teknologi engineering math, gabungan daripada semua itu .

Source: X2

Sample Curriculum goals and technology

Utk autocad kt akan mengajar pada pelajar2 semester 1 , yg mula nak mengenali berkaitan dgn engineering ..nama kod pun engineering drawing , itu utk pelajar sem 1 ..utk pelajar diploma sem 3 , dia terus masuk utk inventor iaitu lukisan upgrading dari 2d ke 3d .

Source: X*1*

.kt kata kt ada topik engine fundamental ..engine fundamental ni utk buat trouble shooting ...cari sesuatu masalah pada sesebuah kenderaan ..antara alat ict atau digital yg kita gunakan adalah scan tool

Source: X*1*

Contoh perisian yang berkaitan dengan inventor itu, lukisan teknikal atau upgrading drawing yang perlu dipelajari oleh pelajar semester 3 diploma automotive , apa yang perlu pihak organisasi atau management perlu cana..atau apabila kita mengadu suatu masalah, inventor ini ada tempoh matinya...apabila dia mati , dia akan mati serentak, sekiranya ada 20 orang pelajar yang nak buat kelas, inventor itu , dia punya license itu telah tamat , maka keburukannya satu kelas tidak boleh belajar, so akses yang kita katakan dalam makmal computer tersebut, kita tidak boleh aplikasikan daripada teori ke amali

Source: X*1*

untuk kita create diagram , boleh daripada situ tetapi untuk create simulasi, tidak dapat . Just kita boleh tengok keadaan litar yang kita buat , mana salah nya tetapi untuk runningnya kita perlu ada simulation sendiri .

Source: X2

untuk motor control , terdapat simulation untuk motor , synchronize motor .

Maksudnya untuk menguji motor tadi , dia ada simulationnya. Berapa kelajuan motor yang kita kehendaki. Contoh sekiranya dikehendaki perjalanan motor dalam bentuk ini, berapa kadar voltnya, berapa ampnya ada

Source: X2

Sample Lesson preparation

Kita dah rancang sedemikian and at the same time kita tidak dapat nak achieve , so apa organisasi perlu lakukan .

Source: X1

Saya masih guna lesson plan conventional. Saya pun..nak ubah ke tidak

Source:X8

Saya tahu, bila saya bercakap dengan students, ada autocad dalam laptop yang boleh pakai

Source:X4

Saya akan guna quizizz..semester ni baru start. Sem lepas belum pandai lag

Source:X4

Sample Assessment

Once kita dah record, dia tidak hilang mana pun kan . Kalau nak buat penilaian, kita boleh sahaja nak buat online . Cuma dari segi hands-on itu sahaja agak susah sikit

Source:X5

Untuk teori kita akan bagi..macam dekat Teams, kita boleh set masa semua ..bila dia submit. Kalau sebelum ni, dia hantar secara copy tu, kita pun tidak tahu, dia hantar on time atau tidak . Kekadang masuk dalam kita punya box pun kita pun tidak tahu . Kalau secara digital kita tahu..oo dia lambat . Kita tahu students mana yang hantar lambat ..kita dah set Tarikh semua . So kita boleh Nampak siapa yang submit lambat

Source:X5

Tunggu pelajar masuk IKM. Bila pelajar masuk sini, mereka buat drawing dan penilaian terus.

Source: X6

Sample Teaching strategies

Aaa kaedah yang Mien gunakan kalau untuk benda yang students baru berkenalan dengan bidang ni kebanyakan Mien gunakan kaedah search internet

Source:X7

Biasanya Mien akan buat slide, satu unit itu kita ambil 2, 3 minggu kan. Kita bahagi-bahagikan mengikut silibus yang bersesuaian. Berapa banyak gambar yang Mien search dan tunjuk dekat students, sampai diorang boleh buka mata.

Source:X7

Ini adalah starting untuk introduction class. Saya normally , saya akan introduce berapa hours, berapa jam kreditnya, apa learning outcome nya dan apakah assessmentnya, iaitu tugas-tugas dan ujian nya yang kita akan assess dalam satu semester. Setiap topik ini bukan sekadar ilmu sahaja tapi ilmu yang akan digunakan bila awak bekerja.

Source:X3

Memos Sorted by Source: X1

Memo ID	Memo	Quote	Author	Date
1	Build rapport	Assalamualaikum wrh, terima kasih lah Nazirul..kesudian nya menjadi utk menjadi pianeer utk kajian rintis lah kt panggil ...kajian kita melihat bagaimana pengajar menggunakan alat ict ()..nt Nazirul bercerita shj ()..bila akak buat pelaporan..jgn risau..nama sebenar tidak digunakan()..	Fariedah LC	Invalid Date
2	Purpose of interview	akak punya projek ni actually..antara akak dengan penyelia shj..tapi projek ini actually, adalah pioneer...sb..yelah..sb tujuaannya untuk membuat satu instrument pengukuran..bila cikgu nak menggunakan alat	Fariedah LC	Invalid Date
3	Start with technical education	mengambil bidang teknikal iaitu di pusat pendidkan institute kemahiran mara Tan Sri Yahya Ahmad, Pekan..	Fariedah LC	Invalid Date
4	content knowledge	sijil teknologi automotive	Fariedah LC	Invalid Date
5	content expertise	bidang diploma air conditioning Baikpulih Penyejukbekuan Refrigeration	Fariedah LC	Invalid Date
6	Industrial experience	Factory Maintenance	Fariedah LC	Invalid Date
7	industry background	kilang tu actually dia buat kulit enjin motosikal..hard disk processor utk computer..dan dia jgk buat tumbling projek utk apa...hanas utk peleburan ..kt sebut sbg copper.	Fariedah LC	Invalid Date
8	industrial job scope	kerja2 yg sy lakukan ialah sy mengawal selia berkaitan dgn bidang MME iaitu mechanical dan electrical ..sy baikpulih bumbung..repairing electrical	Fariedah LC	Invalid Date
9	TVET curriculum	bidang kt adalah dlm komposisi 60:40..60 melibatkan amali..40 melibat (12:40)..teori...sb kt berada dlm tvet jd kt tdk blh lari	Fariedah LC	Invalid Date

		berkaitan dgn teknikal2..dan kt jg tdk blh lari berkaitan teori2..sb klu tidak ada teori dia tdk blh nak support teknika		
10	teaching strategy - teacher centred	dlm pembelajaran explain..terangkan terlebih dahulu ..ni disebut sbg teori	Fariedah LC	Invalid Date
13	hands on	selepas teori kt laksanakan maka amali kt akan lakukan..iaitu dr segi apa yg diperkatakan terus kt tunjukkan dlm bentuk perbuatan	Fariedah LC	Invalid Date
14	teaching strategy - problem based learning	ada masanya sy guna pbl..problem based learning..kt create the problem...kt buat analogi cerita so pelajar sendiri akan memikirkan	Fariedah LC	Invalid Date
15	STEM as tools to solve problems (students)	bagaimana cara dia nak menyelesaikan mslh tersebut dgn menggunakan system STEM td..sains dan teknologi kt gabungkan	Fariedah LC	Invalid Date
16	students background	pelajar diploma dan pelajar sijil..kt dpt bezakan dua2 komposisi tersebut..diploma lain kaedah nya sijil lain kaedahnya	Fariedah LC	Invalid Date
17	teaching method - demonstration	mula kt kena tunjuk cara, kaedah nya dulu	Fariedah LC	Invalid Date
18	group students	kt akan centre kan dia iaitu grouping kan dia.	Fariedah LC	Invalid Date
19	individual task	kt lepaskan dia secara individu	Fariedah LC	Invalid Date
20	teaching method - case study	kajian lapangan atau case study di mana melibatkan grouping.	Fariedah LC	Invalid Date
21	STEM teaching integrated	dlm tvet mara dgn stem ni..s,t,e,m, kt katakan dlm satu subjek..vechicle technologi 2..subjek vehicle teknologi sijil sem 2..ok..kt nak implement kan di mn kedudukan sains..di mn kedudukan teknologi..di mn engineering dan di mn math	Fariedah LC	Invalid Date
23	STEM teaching - integration of 4 disciplines in real life problem	kt ambik satu unit ..dlm trustmission...ada sains nya..calibration nya..kenapa transmission dipasang pd sesebuah kenderaan ..itu yg pertama...yg kedua bagaiman teknologi yg ada ..kt Nampak gear box drpd luar tapi apabila dipasang pd sesebuah kenderaan ..kenderaan tersebut blh bergerak..di mn teknologi nya ..itu yg kedua...yg ketiga engineeringnya..dlm sebuah kenderaan..mcm mn gear box yg kecil itu	Fariedah LC	Invalid Date

		blh menggerakkan sebuah kenderaan ..itu dr segi teknikal engineering nya ..bagaimana penciptaan nya ..matematik..di mn org kata matematik nya dlm gear box...dlm gear box tersebut ada matematik nya..iaitu disebut sbg ..what is the ratio of the gear..bagaimana gear itu dikira nisbahnya ..nisbah itu disebut sbg matematik		
24	Technology in subject taught	teknologi steering..apakah panduan utk kt merekacipta steering ..apakah tujuaan utama steering itu dipasang pd sesebuah kenderaan..so teknologi nya bagaiman kt hendak mengawal..iaitu how to control the steering ..utk membelok kiri dan kanan ..this is the technologi..kt ambik satu part lah..atau teknologi itu merujuk kpd air cond ..klu dulu org selesa dgn membuka tingkap..tetapi bg waktu2 tertentu..adapun pd waktu hujan bagaimana...so..teknologi yg dimaksudkan melihat kpd system penyejukbekuan..apakah tujuan penyejukbukuan itu..tujuan nya memberi keselesaan kpd pemandu dan penumpang kenderaan.. this is the technology ..kt katakana berkaitan dgn teknologi..lepas itu kpd upgrading dia..drpd cooler penyejuk dan heater pemanas..klu negara2 mcm kt hanya memerlukan penyejuk shj ..adapun negara2 yg memiliki 4 musim ..mesti dlm kenderaan tersebut ada nya heater yg disebut sbg pemanas	Fariedah LC	Invalid Date
25	Engineering element in subject taught	ceritakan thermodynamic nya ..adakah kt ciptakan kenderaan tersebut petak semata-mata..lepas itu ada daya penolak angin..so themordynamic nya engineering nya..ialah mcm mn kt hendak lancarkan pergerakkan sesebuah kenderaan ..klu kt tdk bina thermodynamic sesebuah kenderaan tersebut maka kenderaan tersebut sentiasa bergerak melawan arah angin..klu kereta itu flat	Fariedah LC	Invalid Date
26	Math element in subjecy taught	di mn math nya..calculation sebrg perubahan pd sesebuah kenderaan	Fariedah	Invalid

		..matematik tdk blh ditinggalkan dlm rekacipta penciptaan sesebuah kenderaan..bagaimana calculation matematik diaplikasikan..cth pd tayar ..brp size diameter pd tayar..rim nya itu adakah sesuai dgn cth kereta kancil ..kancil cth kt ambil size 12 atau 13..adakah sesuai dipasang dgn tayar hilux..di mn math nya...math nya ada pd R..iaitu roda tersebut klu kt lihat adanya tinggi tayar..lebar tayar..di situlah kt lihat..[semua measurement]	LC	Date
27	ICT tool in teaching - autocad for technical drawing	adanya subjek melibatkan lukisan..engineering drawing (30:42) adanya autocad adanya kartia adanya inventor.	Fariedah LC	Invalid Date
28	ICT software uses for teaching upgraded with 21 century needs	Yg pertama sekali, persian mesti mengikut tahun semasa sb apa ? sb kt nak system yg upgrading.	Fariedah LC	Invalid Date
29	ICT tool in syllabus	sy kaitkan dengan autocad.	Fariedah LC	Invalid Date
30	lesson preparation technology selection based on curriculum needs and students' capability - TPACK	Yg pertama kt sebut sbg perisian.(33:28). Yang kedua ialah apabila kita memilih situasi, iaitu sesuai tidak subjek ni dgn autocad, sesuai tidak dgn pembelajaran pelajar pd masa kini dan pelajar tersebut dia blh adapt tak , apa yg kt ajar dgn system melukis by computer	Fariedah LC	Invalid Date
31	teaching method	kt kn demo terlebih dahulu , kt kata dgn pelajar, cth nya dgn menggunakan alat ICT ni , kt blh melukis bulat..”	Fariedah LC	Invalid Date
33	ICT tool based on TVET syllabus	Utk autocad kt akan mengajar pada pelajar2 semester 1 , yg mula nak mengenali berkaitan dgn engineering ..nama kod pun engineering drawing , itu utk pelajar sem 1 ..utk pelajar diploma sem 3 , dia terus masuk utk inventor iaitu lukisan upgrading dari 2d ke 3d .	Fariedah LC	Invalid Date
34	ICT tool for troubleshooting infield specification	.kt kata kt ada topik engine fundamental ..engine fundamental ni utk buat trouble shooting ...cari sesuatu masalah pada sesebuah kenderaan ..antara alat ict atau digital yg kita gunakan adalah scan tool	Fariedah LC	Invalid Date
35	ICT tool taught in real life@workplace problem	contohnya sebuah kenderaan apabila menyala sahaja lampu check engine , apabila menyala sahaja lampu check engine tersebut maka di situ kita sudah Nampak sains nya , keluar tanda..tanda itu	Fariedah LC	Invalid Date

		menunjukkan kereta tersebut berada di dalam suatu masalah , macam mana kt tahu kereta itu berada dalam suatu masalah , sains nya timbulah lampu , lamp of the check engine , apabila menyala sahaja lampu check engine tersebut sains menunjukkan kenderaan itu ada masalah so you must solve the problem .		
36	ICT tool used in teaching through workplace problem	.sensor tu ada 4 so kita boleh troubleshoot , bila kita troubleshoot menggunakan ict yang kita ada teknologi yang ada dalam scan tool tersebut dia boleh detect dia boleh beritahu yang mana satukah sensor yang mengalami masalah so engineering nya ialah kita dapat detect sensor 1 ke atau sensor 2 , sensor 1 ialah sensor roda bahagian hadapan pemandu sensor 2 ialah sensor di bahagian depan penumpang , sensor 3 ialah sensor yang berada di bahagian roda belakang pemandu sensor 4 ialah di bahagian belakang penumpang hadapan	Fariedah LC	Invalid Date
37	ICT tool youtube to assist in practical teaching - pandemic situation	jadi dengan menggunakan teknologi seperti youtube , atau dengan cara kita buka dan rakam video dan kita tunjukkan kaedah amali tersebut	Fariedah LC	Invalid Date
38	Students' making video for practical class-pandemic situation	kamu boleh buat video buka tayar motorsikal jika kamu tidak ada kenderaan kereta, jadi kamu boleh buka tayar motorsikal , dengan berpandukan video yang saya telah tunjukkan tadi	Fariedah LC	Invalid Date
39	Own video or from youtube ICT tool in teaching	kaedah nya ialah dengan kita menunjukkan video kita atau video yang kita ambil dari youtube dan pelajar tersebut lakukan jugak perkara yang sama atau dia mengambil video rakaman dia membuka dan memasang roda kenderaan	Fariedah LC	Invalid Date
40	ICT to assist in assessment	bagaimana kita melakukan assessment berikut dengan banyak kaedah antara kaedah yang kita lakukan pertama kita pakai google classroom , atau kaedah kedua through online , iaitu minta semua pelajar buka camera , pelajar menggunakan emel yang ada itu , emelkan dalam tempoh masa yang diberikan	Fariedah LC	Invalid Date
41	Students' needs in online	guna pelbagai	Fariedah	Invalid

	learning	kaedah untuk memberi ruang kepada pelajar kita untuk menjawab soalan-soalan , yang pastikan nya pelajar tersebut faham apa yang kita ajar then dia faham apa yang dia sedang jawab semasa task sedang diberikan	LC	Date
42	Managing assessment process	contohnya T1 Test 1 hours yang diberikan assessment yang diberikan adalah 2 jam eh 1 jam setengah contoh nya ..230 hingga pukul 4 mesti habis , dalam situasi pandemic kita mesti bertimbang rasa di situ untuk memastikan pelajar kita menjawab soalan dengan kaedah dan situasi yang kita create ..contoh kita ambil google form , bagi link, hours mesti dah cut ..dah cukup 1 setengah jam , di mesti dah potong betul ? ..yang dah potong macam mana pelajar yang terlambat ..pelajar yang awal tidak apa dah selesai satu bab , yang terlambat daripada nak menjawab itu , so di situ ada juga keburukkannya , maka kaedah yang saya guna satu lagi , kita buat through online ..duduk dengan pelajar sehingga jam 430 katakan , selepas 430 kita bagi kan pelajar tersebut , you must submit all the task before 5 pm , dan dalam masa yang sampai kita mesti guide dia jangan menggunakan kaedah copy and paste..semborono..kamu ini hendak guna copy and paste memang sedap sangat , time pandemic ini sahaja main copy and paste , kalau ada Bahasa indon , terkait semua , kita sebagai pelajar ini kena guide jugak , untuk menjawab kena ada kaedah dan caranya,	Fariedah LC	Invalid Date
43	ICT platform zoom for online teaching	Mula-mula dulu saya pakai zoom, tapi tidak boleh che..sebab kebanyakan latarbelakang pelajar kita ini adalah berbeza locality nya ,, tambah lagi kita yang berada di Sarawak	Fariedah LC	Invalid Date
44	Students' affordances influences selected ICT tool in online teaching	ok boleh lah guna zoom satu dua kali , tapi pada masa yang sama zoom ini agak terhad dan pelajar nak masuk agak berat , agak sukar lah pada awalnya	Fariedah LC	Invalid Date

45	ICT tool in online teaching	kita guna google meet , teams pun kita guna ..daripada ke 3-3 konsep yang kita gunakan ini sehingga 2021 ini ..Alhamdulillah semua pelajar boleh adapt , maknanya ketigatiga ini , kaedah yang kita lakukan ini , zoom, google meet , teams	Fariedah LC	Invalid Date
46	MARA to introduce mircosoft teams as ICT platform but if not compatible to students' affordances, will not be used	teams ni berbayar, zoom pun berbayar tetapi teams ni sdh kita punya MARA punya tetapi pelajar tidak boleh nak ikut sebab dia berat	Fariedah LC	Invalid Date
47	Google meet as ICT tool in online teaching that suits students' affordance	google meet , google meet ni bagus , cun..just satu sahaja dia tidak boleh nak rakam, ada yang boleh merakam tu betul yang berbayar , tetapi kadar penggunaan pelajar kita tidak sampai ke tahap yang berbayar tersebut , buat apa kita nak waste money sebab kita ni dh pandemic, apa yang ada kita gunakan sahaja	Fariedah LC	Invalid Date
48	Experience in own entreprenuer activity contribute to ICT skill	kita ada buat jualan, biasa-biasa sahaja sambal-sambil .Sebelum pandemic, kita telah menggunakan media social ini sebagai medium untuk kita berinteraksi dengan orang, kita selalu buat live streaming , kita bercakap.	Fariedah LC	Invalid Date
49	Problem in wifi accessibility	Cuma pada masa yang sama, kekangan kita adalah line internet tersebut . Itu kekadang kita terasa agak sedikit terganggu .	Fariedah LC	Invalid Date
50	Organization to be awared of curriculum needs in upgrading software license autocad or inventor	organisasi perlu alert dan mesti cangna berkaitan dengan lessen-lesen yang berkaitan dengan sesi pdp yang melibatkan teknologi ini	Fariedah LC	Invalid Date
52	Organization provides relevant ICT tools so that align with curriculum	contoh kita ambil alat untuk alignment tayar kenderaan . Mesin alignment tersebut mestilah dalam full aplikasi . contoh dari sains nya iaitu sensor nya , pasang sahaja tayar ke4-4, sensor perlu baca dan keluar pada engineering , di mana engineeringnya iaitu computer , apa yang berlaku pakai sensor tetapi computer tidak	Fariedah LC	Invalid Date

		dibekalkan ..maka tidak dapatlah apa yang kita sebutkan teknikal vokasional , tidak dapat kita nak aplikasikan teknikal vokasional dalam STEM tersebu		
53	Organization prepares ICT tool that suits and balances other tools in STEM teaching	callabration gear box ..automotic transmission callabration ini ialah selepas kita membuka memasang gear box tersebut , kita kena ada callabration dia , berapakah kesesuaian minyak yang diperlukan , isipadunya tong nya berada dalam sebuah gear box tersebut . Untuk membuat pengiraan, mesti menggunakan mesin ..sekiranya mesin itu tidak ada, kita boleh pakai secara manual, boleh ..tetapi tiada lah stem nya di situ sebab kita tidak ada matematik nya di situ ..ikut suka kita, kalau minyak itu keluar maksudnya penuh lah itu ..perlu ada kesesuaian ICT dan keseimbangan alat-alat , mesti merangkumi ke 4 unsur dalam STEM	Fariedah LC	Invalid Date
54	technology select fit in with curriculum and pedagogy	apa yang kita gunakan sama , match kemahuan TVET MARA dan STEM itu , berjalan serentak dan mengikut silibus yang telah ditetapkan .	Fariedah LC	Invalid Date
55	Online teaching for theory and practical subjectOOOnline	Untuk tempoh pandemic ini, cabaran dan dugaan kita sebagai seorang pengajar ini, lebihlebih lagi pengajar berkaitan dengan bidang teknikal di mana amali akan mengalami sedikit masalah ..adapun bagi teori tidak ..sebab teori kita refer by the book , merujuk kepada buku ini, nota sekian ..kita 'pum pang pun pang' teori selesai kita boleh buat test ..bagaimana kita hendak menyelesai di bidang amali . Amali kita kata selain daripada Nampak sedikit kekangan untuk kita berjumpa secara face to face ..bagi saya yang saya Nampak ialah kita boleh menggunakan pendigitalan . Apa yang saya lihat di sini ialah kita dengan menggunakan sain teknologi engineering iaitu dengan menggunakan teknologi-teknologi	Fariedah LC	Invalid Date

Appendix N: Sample Lesson Plan Coding Theme 1

Codes	Description	Terms represent in Lesson Plan
Curriculum Goals	how the lesson's technologies are directly tied to the core objectives of the TVETMARA curriculum	The technologies selected, such as 'PowerPoint slides, LCD projectors', and 'videos', are strongly aligned with the curriculum goals of TVETMARA. The primary objective of the lesson is to teach 'first-order circuits, energy storage elements, and differential equations' The lesson focuses on teaching students about dimensioning, which is a core aspect of CAD, and the chosen technologies directly support this. 'AutoCAD 2021', as the primary tool, is essential for students to practice dimensioning in a real-world software environment."
Teaching method for Theory and Practical	demonstrates the dual focus on theory (instructional development) and practical application (using AutoCAD software) in the lesson plan, showing a balanced approach to teaching both theoretical concepts and practical skills	The lesson includes both instructional development and hands-on practical application, using 'AutoCAD' to allow students to apply what they have learned in real time. The lesson is largely based on 'lecturing,

		question-and-answer sessions', and 'interactive discussions'. The use of 'Microsoft Teams' facilitates real-time interaction between the instructor and students."
Interdisciplinary Approach	The lesson integrates knowledge from different fields (multimedia, engineering theory, and practical skills) to ensure students can apply what they learn to real-world situations	The content—dimensioning in 'AutoCAD'—is delivered through 'hands-on learning' using the AutoCAD software, allowing students to directly apply the concepts being taught. By integrating 'videos' to explain atomic structures and bonding, the lesson makes abstract concepts more accessible and helps students relate these ideas to real-world engineering scenarios

Appendix O: CLASS OBSERVATION ANALYSIS

EDUCATOR	CK	PK	TK	PCK	TPK	TCK	TPACK	XK
Nazirul (X1) Taught Diploma Automotive Engineering course	-Showed well versed in the field -Mentioned the importance of types of engine and relate it to the field	-used various problems that encounter in teaching subject -kept asking how students were doing and open for discussion	-Google Meet - video from youtube	Using inquiry based learning to scaffolding	Shaped by the online teaching	Using video to demonstrate the types of engine	A weak showed of TPACK The role of ICT in the lesson through discussion in the field problem/trouble shooting	Using ICT tools (Microsoft) from MARA, Inquiry based and discussions
Fabian (X7) taught Electrical Act and Regulations	Showed a mastery in the discussion topic by producing relevant examples of the topics -relate with real examples	- theory class though using a teacher centred approach but the inquiry based during the lessons.	-Microsoft Teams - Powerpoint presentations	Early of the class, emphasize the objectives of the lesson	Online teaching in Teams and sharing screen of slides presentations	ICT to support content not presented	The blend of CK, PK and TK at the minimum level. TK was used to support the online teaching and visual presentation	ICT tools provided by TVETMARA, learning outcomes , inquiry based
Nurul (X4) taught Course Computer Aided Design 1	She introduced the objective of the lesson – mentioned ' moving from drawing manually to drawing using CAD'	She attempted to fulfill the visual, audio and kinesthetic (animation) in her slides presentation She used lots of	The used of Autocad software for technical drawing class	The integration of technology , mathematics and engineering disciplines in the context of Technical Drawing class	Teams Microsoft to conduct her online class	Autocad as a software that used in engineering technical drawing	She fits in the C,P and T to balance the types of knowledge	She well versed with TVETMARA curriculum needs, request students' peers to assist on the

		demonstration in the early class before assigning task to her students						AutoCAD software
Zakhlis (X9) taught theoretical class 'Keluli dalam Struktur'	Displayed his mastery in the course taught, teaching confident tone	Arranged the flow of the lesson from easy to difficult. With q & a , each problem was followed with workplace examples	Screen sharing in Microsoft Teams using Powerpoint slide presentation with video	The flow of the of the content from easy to difficult makes students able to grasp, students could answer questions	Using visual presentation in the powerpoint and video slides to show the abstract structure of steel	Video presentation to support content	A balance illustration of C,P and T. However, still using low level of ICT tools (video, slide)	Abide to TVETMARA curriculum goals by using Microsoft as the organization provider
Nizam (X10) taught theory and practical for Pneumatic and Hydraulic	Exhibited subject master expert in the subject with details explanation , examples of instrumentations shown	Elements of problem based learning by using workplace	Use slide powerpoint with own video of using simulators	Structure of teaching from easy to difficult with starting of basic explanations help students to understand the practical instruments	Screen sharing in Microsoft Teams to support online teaching	Used of simulator to depict the actual scenario in instrumentation	Strong with C and T , and moderate P , with less interaction with students	Learning outcomes of the course was shared with the students
Osman (X3)) taught Project Management class	Exhibited the mastery of practical sight of engineer. Showing how technology such	Exhibit preparation of PBL and taking account with different students	Using fully Microsoft platform with familiarity	Since he was teaching the preparation in engineer workflow, having group	Using class point in PowerPoint makes the class to be interactive	Microsoft project tool assists the work of an engineer	For project management course combine with ICT tools used display the	Align with TVETMARA curriculum and course outcomes, lecture

Appendix P: Sample of Lesson Plan

LESSON PLAN

PROGRAMME :	DED		
SESSION :	MEI - OKTOBER 2021	**SEMESTER :**	2
CODE & COURSE :	DEV 21053 - ELECTRIC CIRCUIT THEORY 2	**SHEET NO :**	LP 01
NO OF STUDENTS :	17 STUDENTS	**WEEK :**	1
DURATION :	5 HOURS	**VENUE :**	MEE
LECTURER :	OSMAN BIN ABU BAKAR		

TOPIC :	**UNIT 1 : FIRST ORDER TRANSIENT ANALYSIS**
SUB-TOPIC :	1.1 Introduction circuit with First Order Differential Equation
TOPIC LEARNING OUTCOME :	At the end of the lesson, student should be able to :- 1. Describe a first-order circuit. 2. Explain the characteristic of energy storage Element

INSTRUCTIONAL AIDS	TITLE	CODE NO/QUANTITY
WRITTEN INSTRUCTIONAL MATERIALS	Information sheet	IS 01
AUDIO VISUAL AIDS	LCD Projector, Power Point Slide, Laptop	1
TOOLS/EQUIPMENTS	White board Marker pen	1 2

STAGE/TIME	TEACHER ACTIVITIES	STUDENT ACTIVITIES	REMARKS
INTRODUCTION (15 minutes) Induction Set Prior Knowledge	• Explain to the students about the objective of the lessons. • Show a actual model, picture and video about the topic lesson • Ask the students about the topic	• Students pay attention and write notes. • Give attention and response.	• Actual model, picture and video
DEVELOPMENT (Phase 1) (1.5 hours)	• Explain about first Oder Transient State and analysis. • Explain about First-order diferencial equation • Explain about First-order RC Circuits. • Give an example and show the solution	• Students pay attention and write notes. • Students write notes into their books. • Students pay attention and write notes	• Use LCD projector • Information Sheet (IS01)
(Phase 2) (2 hours)	• Give Simple Exercise Sheet 1 for differencial equation. • Ask student answer the question	• Students pay attention and write notes.	• Exercise Sheet 2

STAGE/TIME	TEACHER ACTIVITIES	STUDENT ACTIVITIES	REMARKS
SUMMARY	• Test the students unnderstanding by asking the students a few questions about the concept which they have learn today. • Ask a few students and give chance to other students to help their friends. • Give complementation to students if the answers were correct. • Make sure the comprehension of the students is achieved through the questions. • Preview to the students about the next topic that is '**Step Response**"	• Students give responds to the questions which have been given to them. • Answer the question	

EVALUATION :

1. Give instruction to the students to answer the questions in the Exercise Sheet 1.
2. Tell the students to answer the question and hand in the answer in the next class.

REFERENCE :

1. Charles K. Alexander & Matthew N. O. Sadiku, 2009, **Fundamentals of Electric Circuits**, 4th Edition, McGRAW.HILL
2. Richard, A.S James, 2004, **Introduction to Electric Circuit**, 6th Edition, John Wiley.

Appendix Q: Sample SPMa Instrument

STANDARD AMALAN 1: AMALAN PROFESION PENDIDIK MARA

BKT

NO. ASPEK	ASPEK	NO. ITEM	ITEM	PK		PV
1.1	Pedagogi	1.1.1	**PM dapat menggunakan pendekatan Konstruktivisme** i. Menggunakan kaedah inkuiri atau pembelajaran melalui pengalaman. ii. Pembelajaran melibatkan usaha secara kolaboratif dan tidak menitikberatkan persaingan. iii. Konsep dibina berdasarkan refleksi bermakna, pengalaman dan pengetahuan sedia ada pelajar. iv. Mengaitkan konsep yang dipelajari dengan konteks pengalaman pelajar. v. Pengajaran mengambil kira tahap kesediaan, perasaan dan sikap pelajar. vi. Memberikan masa yang mencukupi untuk pelajar memproses maklumat dan menghayati apa yang dipelajari. vii Pelajar diberikan kes/masalah mencabar yang menyerupai situasi sebenar (real world problems/pembelajaran melalui projek sebenar) viii Menggunakan kaedah *Problem Based Learning* Skor 4 : Mana-mana empat atau lebih di atas Skor 3 : Mana-mana tiga di atas Skor 2 : Mana-mana dua di atas Skor 1 : Mana-mana satu di atas Skor 0 : Tiada		Catatan	
		1.1.2	**Aktiviti Pengajaran dan Pembelajaran (PdP) berpusatkan pelajar** i. Pelajar diberi peluang merancang dan menentukan kaedah pembelajaran. ii. PM memberi sokongan kepada pelajar untuk menjalankan aktiviti pembelajaran pilihan mereka.		Catatan	

Appendix R : Sample Quotes X2

Memo ID	Memo	Quote	Author	Date
56	Pedagogy class	Dulu nya pedagogy F: Oh pedagogy Z: Nya ada code number TM 001 F: oh ok2, pas ya kitak molah di mana Z: Masa ya di Ciast, Shah Alam F: Alright okay Z: 3 bulan lah, direct 3 bulan and then lepas 3 bulan, kemudian 6 bulan ya intensif lah maksudnya ada pemantauan	Fariedah LC	Invalid Date
57		Dulu nya pedagogy F: Oh pedagogy Z: Nya ada code number TM 001 F: oh ok2, pas ya kitak molah di mana Z: Masa ya di Ciast, Shah Alam F: Alright okay Z: 3 bulan lah, direct 3 bulan and then lepas 3 bulan, kemudian 6 bulan ya intensif lah maksudnya ada pemantauan F: Oh okay, so nak internship tok kitak molah di IKM kah? Z: Nya akan turun ke IKM, nya akan observe kamek org lah F: Oh ok2 Z: Nya menilai dari segi sama ada teori, tapi kamek org hari ya teori dgn amali nya menilai cara mengajar sekali dgn dokumentasi F: Termasuk...kitak org pake wim nak oh Z: Pake wim, wim yg dikeluarkan oleh Ciast, nya nilai sia lah F: Tapi sebenarnya wim tok sama ja ceritanya, lesson plan nya sama ja Z: Sama ja, format nya sama nya ada 4 step pattern, semua sama sebenarnya cuma reka bentuk nya muka depan nya lain tapi isi dalam nya sama F: Alright okay, menarik2 ya lah tek dapat juak	Fariedah LC	Invalid Date
58	How pedagogy class was conducted	Dulu nya pedagogy F: Oh pedagogy Z: Nya ada code number TM 001 F: oh ok2, pas ya kitak molah di mana Z: Masa ya di Ciast,	Fariedah LC	Invalid Date

		Shah Alam F: Alright okay Z: 3 bulan lah, direct 3 bulan and then lepas 3 bulan, kemudian 6 bulan ya intensif lah maksudnya ada pemantauan F: Oh okay, so nak internship tok kitak molah di IKM kah? Z: Nya akan turun ke IKM, nya akan observe kamek org lah F: Oh ok2 Z: Nya menilai dari segi sama ada teori, tapi kamek org hari ya teori dgn amali nya menilai cara mengajar sekali dgn dokumentasi F: Termasuk...kitak org pake wim nak oh Z: Pake wim, wim yg dikeluarkan oleh Ciast, nya nilai sia lah F: Tapi sebenarnya wim tok sama ja ceritanya, lesson plan nya sama ja Z: Sama ja, format nya sama nya ada 4 step pattern, semua sama sebenarnya cuma reka bentuk nya muka depan nya lain tapi isi dalam nya sama F: Alright okay, menarik2 ya lah tek dapat juak		
59	Pedagogy class Ciast	Sebab bila kita pergi ke sia , sidak akan tanya engkau ada pedagogi sik? Ada dari Ciast KM 001. Macam kamek orang KN 0001..macam kamek orang adalah jenis orang lama-lama kononnya. Yang baru-baru tok sahaja yang ...start daripada 2000 berapa ya guna sistem VTO. Kami generasi KM 0001, 3 bulan direct dan kemudian 6 bulan internship di tempat masing-masing. Sekiranya kami hendak convert ke VTO, kami hanya perlu interview jak. Ada sesi interview.	Fariedah LC	Invalid Date
60	Ciast vs VTO	Mun VTO tok ia sekali dengan SKM . Macam kamek orang dolok sik ada , Cuma dipanggil sebagai pedagogi sahaja. Yang baru tok nya ada VTO, pedagogi sekali dengan SKM. Mengikut tahap berapa ketinggiannya , ya lah perbezaan pedagogi nya.	Fariedah LC	Invalid Date
61	years of teaching experience	yalah 17 tahun dah mengajar dengan MARA . Masuk 2004 bulan 9	Fariedah LC	Invalid Date

62	Subject matter expert	pengajar dalam bidang elektrikal . Di bawah jabatan elektrikal IKM Kuching	Fariedah LC	Invalid Date
63	technical field in electrical-certificate	belajar ke IKM Kuching selama 2 tahun dalam bidang Elektrikal	Fariedah LC	Invalid Date
64	diploma HND level BMI	diploma pergi ke British Malaysia Institute dari tahun 2000 sehingga 2001, 2 tahun.	Fariedah LC	Invalid Date
65	content knowledge	Diploma Electrical and Electronic Engineering, bawah Higher National Diploma in Electrical and Electronic.	Fariedah LC	Invalid Date
66	years teaching	17 tahun telah berkhidmat dengan IKM Kuching.	Fariedah LC	Invalid Date
67	industrial experience	1 tahun lebih sikit. Dan balik baru bekerja di area Kuching (13:42)..dalam bidang industri dan masih dalam bidang yang sama iaitu dalam bidang elektrikal	Fariedah LC	Invalid Date
68	industrial experience	70% adalah wiring dan 30% adalah bahagian mekanikal macam lebih ke motor mekanikal ...gabungan elektrikal dan mekanikal.	Fariedah LC	Invalid Date
69	defining STEM	sains teknologi engineering math, gabungan daripada semua itu .	Fariedah LC	Invalid Date
70		STEM memang banyak kepada sekolah..dipratikkan.	Fariedah LC	Invalid Date
71	opinion on STEM- seeing STEM as pedagogical practice	STEM memang banyak kepada sekolah..dipratikkan. Tapi di peringkat kita, apa yang saya faham, tidak secara menyeluruh, tapi ada berlaku ...ada bersangkut paut dengan kaedah yang kita gunakan mengajar di MARA . Contohnya pada hands-on amali..dari segi teori , perbezaan teori dulu dan sekarang.	Fariedah LC	Invalid Date
72	Pandemic ignites/sparks use of ICT in teaching	dalam keadaan covid atau abad ke 21 ini terdapat perbezaan. Sebelum Covid, teori kita berhadapan dengan pelajar , face to face ..tapi dalam keadaan sekarang, kita bersama dengan pelajar dalam penggunaan ICT	Fariedah LC	Invalid Date

73	Autocad software for technical drawing	autocad adalah sebahagian daripada ya . Sebenarnya, untuk melukis ada juga program yang kita boleh gunakan.	Fariedah LC	Invalid Date
74	Use of autocad and need software to create simulator	untuk kita create diagram , boleh daripada situ tetapi untuk create simulasi, tidak dapat . Just kita boleh tengok keadaan litar yang kita buat , mana salah nya tetapi untuk runningnya kita perlu ada simulation sendiri .	Fariedah LC	Invalid Date
75	organization target	benda ya dah dalam proses pendigitalan , kan Pengarah kita mahu minta dan next nanti akan digunakan sepenuhnya	Fariedah LC	Invalid Date
76	online teaching	kita hanya menerangkan dengan pelajar secara biasa sahaja di atas whiteboard. Dan jika secara online, kita just tunjuk secara online menggunakan nota dan sebagainya .	Fariedah LC	Invalid Date
77	Simulator as one of the ICT tools in teaching	untuk motor control , terdapat simulation untuk motor , synchronize motor . Maksudnya untuk menguji motor tadi , dia ada simulationnya. Berapa kelajuan motor yang kita kehendaki. Contoh sekiranya dikehendaki perjalanan motor dalam bentuk ini, berapa kadar voltnya, berapa ampnya ada	Fariedah LC	Invalid Date
78	organizationl financial support	di bawah RMK 12 , kalau tidak silap...untuk pembelian DCS diploma	Fariedah LC	Invalid Date
79	STEM teaching with the assist of simulator as teaching aided tool. Fit in with the curriculum , teaching strategies used and students background - TPACK	Kebanyakan subjek yang menggunakan simulation ini lebih untuk tajuk Power...Kuasa. Contoh , apabila dalam semester 1, semester 2, ataupun Semester 3..untuk diploma, apabila dah semester 3, advance kepada mesin-mesin yang ada . Jika 1 dan 2, selalunya akan belajar basic. Bila semester 3 ke atas, sehinggalah semester 6, dipanggil sebagai advance technology .Mereka akan belajar lebih lagi daripada sijil. That’s why mesin-mesin itu kita beli untuk pembelajaran mereka. Diploma lah..Simulator ada. Yang kita beli untuk kita pakai . Pelajar akan guna bersama dengan cikgu, Cikgu akan terang . Pelajar akan guna sekali. Sama juga dengan teknologi solar. Renewable energy. Kita ada solar dan turbine. Turbine ini adalah angin.	Fariedah LC	Invalid Date

80	STEM teaching example Renewable Enegry	Ia dalam tajuk teori..tapi ada sub-topik nya Renewable Energy. Maksudnya kita ada angin. Jadi daripada angin , kita boleh jadikan nya sebagai tenaga. Dengan menggunakan kincir angin. Sekiranya kita ada air, kita akan gunakan turbine. Turbine bila nya berpusing, ia akan menghidupkan..so ia energize kan. Jadi akan menjadi tenaga. Sama dengan solar. Solar menggunakan cahaya. Cahaya matahari memancarkan nya, jadi ia akan bertukar menjadi kannya tenaga.	Fariedah LC	Invalid Date
81	STEM teaching example that includes calculation and science	Contoh solar , memang ada pengiraan . Contoh untuk memasang solar di rumah kita sesuai atau tidak, ada calculation khusus. Kita kena tahu di mana arah matahari , berapa ketinggian matahari , di sini lah kita akan guna maths .	Fariedah LC	Invalid Date
82	Opinion on STEM teaching	Memang berlaku STEM di TVET, Cuma kita tidak perasaan	Fariedah LC	Invalid Date
84	Technology is defined as a tool that support the engineering field	Solar ini datang daripada cahaya iaitu sains . Macam mana kita hendak mengolah cahaya tadi menjadi tenaga ..dengan menggunakan satu teknologi. Kita wujudkan satu teknologi untuk menangkap cahaya , menyerap cahaya supaya menjadi tenaga. Memang dah ada dalam gabungan ..melalui solar dan turbine.	Fariedah LC	Invalid Date
85	students' background	Ini untuk pelajar sijil. Untuk pelajar diploma, IQ untuk matematik adalah lebih advanced sikit daripada sijil, Mana yang pandai memang pandai lah. Yang kurang nya boleh catch up.	Fariedah LC	Invalid Date
86	example of STEM teaching	Di mana wujudnya atom..sains . Kemudian electron ..barulah jadi current. Di sinilah Principle basic, apabila basic . Then baru pergi ke calculation.Calculation untuk litar-litar...litar terbuka..litar tertutup. Mula-mula tadi sains berkenaan atom..macam mana berputar, kenapa berputar . Macam mana kita hendak ia berputar supaya ia akan menjadi sebagainya...ada teknologinya. Kemudian dalam engineering, kita pratikkan dari segi pengiraan engineering. Jadi dalam technical, kita gunakan gabungan math, iaitu	Fariedah LC	Invalid Date

		menggunakan teorem pithagoras, itu ada juga. Ini lah Principle, ia memang complete.		
87	used of ICT parallel with 21st century needs	Hanya diploma, pembelajaran adalah lebih advanced...sebab penggunaan teknologi yang terkini kebanyakkannya.	Fariedah LC	Invalid Date
88	Opinion on STEM teaching	Memang ada. DI IKM ini, STEM memang ada...bukan setakat satu dua subjek tetapi kebanyakkannya.	Fariedah LC	Invalid Date
89	Covid cause for online teaching	disebabkan Covid. Jadi kelas kebanyakkannya secara online.	Fariedah LC	Invalid Date
90	ICT tools used for online class - google meet, microsoft teams, email Constraint to use certain online platform	ICT yang saya gunakan sepanjang sesi MeiNov, kelas teori dijalankan secara atas talian. ..menggunakan google meet. Pernah cuba menggunakan Teams...tetapi pelajar setelah diberi emel..saya pernah cuba sekali. Dari segi internetnya, apabila menggunakan Teams, ia jadi slow sikit. Kekangan kita..sebab itu, saya lebih suka guna Google Meet. Tetapi masalahnya tidak dapat direcord.	Fariedah LC	Invalid Date
91	students background	keselesaan...sebab kebanyakan pelajar ..bukan semuanya berada di bandar sekarang ini. Kebanyakkannya datang daripada pelusuk luar bandar. Sebab saya ada 3 orang pelajar ini..termasuk seorang daripada Sabah.	Fariedah LC	Invalid Date
92	Managing students attendance	Sebab mereka memaklumkan juga..contoh 'Che, tidak dapat untuk hari ini. Saya akan cuba..tapi perlu ke bukit tinggi sikit untuk dapatkan line.". Bayangkan sampai tahap begitu. Ini tidak ada masalah. Yang penting, pelajar contact saya . Maksudnya tidak putus.	Fariedah LC	Invalid Date
93	ICT tool whatsapp	he, kalau dapat saya masuk, kalau tidak dapat, saya whatsapp"..ICT lah kan..whatsapp saya guna. Kelas beronline menggunakan Google Meet.	Fariedah LC	Invalid Date
94	Assessing students using google form	untuk penilaian, saya menggunakan google form...untuk penilaian ke atas pelajar	Fariedah LC	Invalid Date
95	Online teaching with considering	dalam pengajaran saya menggunakan Google Meet. Dari segi	Fariedah	Invalid

	students affordances in ICT tool	berhadapan dengan pelajar, present semua melalui Google Meet. Ini sahaja platform yang digunakan buat masa ini. Mircosoft Team pernah guna sekali . Tetapi disebabkan permintaan pelajar tadi, tidak mahu ..sebab payah, slow che..Jadi tukar balik ke Google Meet.	LC	Date
96	Managing class with lesson preparation by preparig notes in GC/whatsapp. Anyflip for digitilization purpose	GC memang telah digunakan sejak dari sesi lepas dan diteruskan dengan sesi ini...di mana saya letakkan information sheet ke dalam nya. Tetapi kekadang pelajar tidak dapat nak buka so saya turut send dalam whatsapp tetapi kita buat secara anyflip...di mana ia akan dibukukan supaya students tidak dapat buat apa-apa dengan nota saya. Mereka hanya boleh membaca sahaja. Kemudian penilaiaan, memang menggunakan google form.	Fariedah LC	Invalid Date
97	Teaching strategy with discussion and used of video	Discussion serta perbincangan semua ada, dan turut disediakan video juga untuk tontonan pelajar. Contoh subjek saya ini lebih kepada ..sem4 DCS ini lebih kepada subject advanced .Contoh lebih kepada overhead line dan underground dan menceritakan segala apa yang berada di underground serta apa yang berada di overhead...cerita berkenaan overhead line.	Fariedah LC	Invalid Date
98	Video to help to assist in hands-on class	ila kita di bengkel, certain ada yang kita perlu tunjuk secara live dan certain yang kita tunjuk secara video. Kekadang pelajar tidak tahu apabila kita sebut nama contoh heatshrink..tahu tak heat-shrink?" Tidak tahu che'..macam mana rupa heat-shrink?" Kalau dalam bahasa melayu adalah hangat kecut..ia adalah sejenis getah. Apabila kita masukkan untuk joint cable, apabila kita dah potong cable dan kita nak join kan cable balik ..ia jadi penebat, kita nak tutupkan, getah kita bakarkan , bila panas ia akan kecut...jadi ia akan ketat. Itu lah heat shrink. Pelajar tidak tahu. Tetapi apabila kita berhadapan dengan pelajar , mereka boleh nampak.	Fariedah LC	Invalid Date
99	Class management	Sekiranya kita bercerita secara online, ada pelajar tidak faham, so apabila pelajar tidak faham dan tidak tahu rupa bahan itu, saya	Fariedah LC	Invalid Date

		akan bagi link (40:55)..awak cuba buka link ini dan tengok.		
100	Preparing teaching materials	Maksudnya belum saya buat penerangan, bahan itu dah ada..sediakan terus . Readykan terus bahan yang ingin di share supaya mereka nampak. Kita tidak boleh beritahu student ini heat shrink dan cari sendiri link	Fariedah LC	Invalid Date
101	Teaching strategy using 2 way communication with inquiry based, alert with students behaviour, hybrid of teacher and student centred	Untuk saya, dari segi pengajaran, saya tidak mengajar secara direct. Ada part saya akan berhenti..tanya students ada soalan tidak. Jika kita teruskan, pelajar akan diam sahaja. Asyik tanya pelajar, faham tidak...sampai 5 kali . Kalau style saya, saya akan sentiasa alert dengan pelajar ..kalau boleh, memastikan pelajar 'on' kan video mereka ..camera mereka. Supaya tahu apa yang berlaku kepada mereka . Itu yang asyik tanya faham tidak...faham tidak...sampai 2, 3 kali . Jadi saya akan ada sesi berhenti...macam buat penerangan 10 minit dan berhenti , tanya mereka...buat penerangan, berhenti dan tanya dan berterusa	Fariedah LC	Invalid Date
102		Untuk saya, dari segi pengajaran, saya tidak mengajar secara direct. Ada part saya akan berhenti..tanya students ada soalan tidak. Jika kita teruskan, pelajar akan diam sahaja. Asyik tanya pelajar, faham tidak...sampai 5 kali . Kalau style saya, saya akan sentiasa alert dengan pelajar ..kalau boleh, memastikan pelajar 'on' kan video mereka ..camera mereka. Supaya tahu apa yang berlaku kepada mereka . Itu yang asyik tanya faham tidak...faham tidak...sampai 2, 3 kali . Jadi saya akan ada sesi berhenti...macam buat penerangan 10 minit dan berhenti , tanya mereka...buat penerangan, berhenti	Fariedah LC	Invalid Date

		dan tanya dan berterusan. Contohnya kalau 2 jam, dalam tempoh 2 jam akan ada sesi untuk dapatkan feedback pelajar dan dari cara begitu. Jika ada soalan, mereka akan terus tanya...dan kita akan terus bincang. Sekiranya tidak dapat dijawab, kita akan bagi link tadi. Rujuk pada link ini...untuk membantu saya juga. Untuk memberi penerangan terus, lain lah jika kita berdepan dengan pelajar...face to face.		
103	ICT used to assist in teaching	Tapi sekarang kita secara online, jadi kita gunakan ICT yang ada ini untuk membantu untuk mereka merujuk semula.	Fariedah LC	Invalid Date
104	ICT tool to assist in demostration phase	Kebanyakan begitu..pengiraan akan terlibat untuk sem 6. Pernah dibincangkan di peringkat bengkel juga, untuk pendigitalan , apa bahan yang hendak dibeli di peringkat bengkel dan jabatan .Dan salah satu yang kami target untuk beli adalah untuk menulis tadi...pen ...notepad. Kita tulis dekat pad dan terus link , view pada komputer . Pernah dibincangkan untuk membeli supaya senang untuk menerangkan...dan kita akan berterusan secara online .	Fariedah LC	Invalid Date
105	Opinion on ICT as teaching tool aid	Sebelum ini, apa yang kita tahu, kita hanya guna komputer , lcd projektor dan kita tidak terfikir kita akan menggunakan whatsapp untuk pembelajaran ..tetapi hanya digunakan untuk komunikasi sahaja. Tetapi apabila berlaku keadaan ini, macam telegram , whatsapp..kita gunakan kaedah ini untuk pembelajaran kita selepas ini.	Fariedah LC	Invalid Date
106	21st century and covid pusher for ICT usage in teaching	berlaku abad ke 21 ini, dengan Covid lagi..jadi penggunaan nya menyeluruh. ..keadaan memaksa kita untuk memakai. Sebelum ini, tidak terfikir pun untuk menggunakan untuk mengajar...sekadar hanya untuk berkomunikasi sahaja .	Fariedah LC	Invalid Date
107	ICT change pedagogy practice but	untuk kita pengajar, pedagogi kita..adakah alat ICT menukar	Fariedah	Invalid

	delivery still maintain.	pedagogi kita? 100% menukar..menukar kaedah kita . Tapi dari segi penyampaian kita iaitu 4 step patterns tidak akan lari ..content masih maintain..Cuma kaedah penyampaian dengan pelajar ..menjadikan pelajar lebih faham.	LC	Date
108	Training in the used of ICT for teaching	Training itu memang membantu dari segi menyelesaikan untuk kaedah kita mengajar	Fariedah LC	Invalid Date
109	mentoring from colleague and self discovery	ita ada juga kawan-kawan yang pakar, yang kita boleh pelajari daripada mereka .	Fariedah LC	Invalid Date
110	Students' competency ICT is enhanced through work given	Tapi akan suggest pada pelajar, jika nak tahu lebih mendalam, perlu explore lagi..penggunaan tidak putus di peringkat saya dan di peringkat pelajar. Saya akan menyampai menggunakan ICT yang ada, kemudian pelajar akan menggunakan balik ICT yang kita suggest tadi ..jadi ia berterusan.	Fariedah LC	Invalid Date
111	assesing student work	ita hendak student hantar assignment , dengan hand writing ...yang bertulis tangan . Apabila bertulis tangan, pelajar kena hantar dengan saya dalam pdf . Jadi pelajar kena ambil gambar dan convert dalam pdf dan send dengan kita. Ada pelajar yang tidak tahu ..dan di sanalah kita akan mengajar pelajar tersebut penggunaan ICT lagi ..” Awak ambil gambar, selepas ambil gambar then awak convert ke dalam pdf then baru send dengan saya . Jadi penggunaan ICT dengan pelajar tadi, kita turut mengajarnya ..jadi mereka pun tahu supaya penggunaan berterusan.	Fariedah LC	Invalid Date
112	constraint in conducting hands-on using online teaching	Sebab itu pelajar perlu dipanggil untuk hands-on mereka. Bagi saya, untuk elektrikal ini, tidak boleh ...ada yang suggest, kenapa tidak buat secara online. Contoh kita tidak mahu pelajar berhadapan dengan kita , jadi mereka suggest untuk kita buat amali secara maya. Tetapi apabila difikirkan balik, elektrikal ini melibatkan benda yang ada supply current . Jadi kalau kita hendak	Fariedah LC	Invalid Date

		student buat secara maya, bagi saya tidak terlalu pratik		
113	opinion on use of simulator as teaching aided tool for practical	Ya, biar pelajar ini berhadapan dengan kita dan kita boleh pantau. Jika mereka di luar..Cuma satu kaedah guna simulation tadi. Kita beri dengan pelajar..masing-masing ada simulation , mereka boleh gunakan dan kita pantau. Cuma tidak secara real...Tapi jika pelajar buat secara demikian, di situasi sebenar, mereka akan blur . Jadi perlu juga mereka untuk turun dan buat hands-on, ini adalah pendapat saya.	Fariedah LC	Invalid Date
114	assessment conduct in online mode using video and camera	Tetapi buat masa ini belum tahu lagi akan keputusan. Kemungkinan dibuat secara online atau face to face...antara dua. Bayangkan, jika dibuat secara online, cadangan mereka , pada peringkat IKM kena sediakan video ..maksudnya camera. Kamera ini akan di pancar setiap sudut di bengkel ..pelajar akan melakukan secara real.	Fariedah LC	Invalid Date
115	tvet curriculum	ntuk pelajar kita, bila mereka keluar nanti mereka akan dapat sijil kompeten, satu..satu lagi adalah JPK. JPK ini adalah penilaiannya adalah lebih kepada amali. Macam mana juga, bagi saya, untuk elektrikal..pelajar perlu masuk dan perlu buat juga hands-on secara real.	Fariedah LC	Invalid Date
116	Organization support financially for digitalization purpose	Pengurusan IKM sebelum ini, dan perkara ini pernah dibincangkan di peringkat bengkel ..daripada BKT sebenarnya yang minta..lepas itu pergi ke pihak pengurusan...dan pengurusan minta dan turun kepada bengkel ..untuk lebih kepada pendigitalan ini...support dari pihak pengurusan memang sudah ada. Kita sudah ada bajet . Cuma untuk kami sebagai pengajar, apa yang kami hendak beli , apa yang patut dibeli. Contohnya..untuk melibatkan pengajaran secara online ..alat ICT yang perlu. Kita dah ada bajet yang datang daripada pihak pengurusan , pihak atas iaitu organisasi . So support itu memang dah ada.	Fariedah LC	Invalid Date
117	Digitalization project from	Ya..memang perlu. Sekarang ini, salah satu nya adalah bilik	Fariedah	Invalid

	organization	pendigitalan telah diwujudkan. Sekarang ini dalam proses tengah dibuat. Kalau di bengkel kami, memang tengah dibuat. Cuma bilik itu adalah bilik pendigitalan ..dan bilik dah ada, maka perlu lah ada penambahan bahanbahan ICT, untuk pembelajaran kita kelak. Memang ada lah support daripada organisasi..bajet dah ada. So organisasi dah support dan memberi kerjasama ..apa yang perlu dibeli, boleh beli	LC	Date
118	Autocad cad electrical drawing	Memang tajuk nya autocad juga. Software yang digunakan adalah autocad. Tapi tajuk nya dipanggil electrical drawing. Softwarenya adalah 100% autocad.	Fariedah LC	Invalid Date

X8

Memo ID	Memo	Quote	Author	Date
119	Subject matter expert	dalam bidang elektrik,	Fariedah LC	Invalid Date
120	Years of teaching experience	ebih kurang 10 tahun	Fariedah LC	Invalid Date
121	STEM expert background	diploma dalam bidang elektronik kawalan di Politeknik Johor Bahru . Sekarang ni dah tukar ke Politeknik Ibrahim Sultan . Then saya juga mempunyai ..pemegang ijazah sarjana muda dalam bidang elektrik di Universiti Teknikal Malaysia Melaka dan saya further study sampailah bidang elektrik kuasa di Universiti Teknologi Malaysia..dalam ijazah..dalam Master degree. Dan sekarang ni tengah further di Universiti Malaysia Perlis di UNIMEP dalam bidang kejuruteraan ..Doktor Falsafah dalam bidang Kejuruteraan dan bidang research interest saya lebih kepada bidang elektrik dalam sistem perlindungan ..voltan tinggi dan juga () dan juga grounding ..inilah research area or focus saya.	Fariedah LC	Invalid Date
122	Industrial experience	Pengalaman dengan industry kalau lepas belajar itu adalah 3 tahun ..duduk di industry perkilangan iaitu manufacturing ..Yang pertama di kilang elektronik di Shah Alam. Dan kedua di kilang pembuatan hard disk ataupun hard crust computer di Johor. Jadi masa yang lama tu banyak dihabiskan di..nama syarikat tu Western Digital . Jadi kalau di Kuching tu di ..Sarawak pun ada Western Digital . Saya pernah ke sana travel..ada dua kilang tu ..kekadang saya ada ke Kuching juga. Apabila saya masuk MARA dalam perkhidmatan, dapat Latihan sangkutan industri pada tahun 2020. Awal tahun 2020 sampai hujung 2020 . Setahun Bersama satu syarikat ..syarikat consultant di kota bahru , Kelantan. Pada tahun 2019 , lebih kurang 3 minggu ..yang ini Latihan Sangkutan Industri as contractor	Fariedah LC	Invalid Date

		..juga di Kelantan...lebih kurang 3 bulan. Saya tidak berapa ingat Tarikh nya. Jadi yang tahun 2020 , saya attach dengan consultant ni ..consultant elektrik . Antara nya disebabkan saya join program dengan KKTM Pasir Mas iaitu Pembangunan Jurutera Professional .		
123	Familiarity with STEM teaching term	Saya biasa dengan STEM sahaja..sains, teknologi, engineering dan mathematics. Tetapi apabila focus kepada teaching..hari ini lah baru pertama kali	Fariedah LC	Invalid Date
124	teaching method distinguishes theory and practical class	Teaching method saya bergantung kepada kursus lah. Kalau kursus itu penuh dengan teori, 100% teori, jadi teaching method saya ke arah A, contoh lah..kalau kursus tersebut ke arah amali..ada yang 70% amali atau ada yang 100%. Jadi lebih kepada amali..contohnya kalau kita tengok amali atau saya panggil method B ini, Pertama untuk method B ini banyak kepada demonstration dahulu. Saya demo dahulu, ada yang berkali-kali, repetitive action dan selepas demo, baru saya minta pelajar buat.	Fariedah LC	Invalid Date
125	Autocad drawing Concerned for students' readiness Teaching technique	Dalam autocad ini, bila kita tunjukkan software kepada pelajar , gerakkan arahan ke command window dan sebagainya . Untuk pelajar ini adalah pertama kali dan baru untuk dia. Setiap sesi kelas itu, akan ada benda baru yang dia dapat. Jadi saya kena tunjukkan demonstration itu dulu ..contoh command draw..command draw ini apa akan belaku...command erase apa akan berlaku. Jadi saya akan tunjuk ..tunjuk-tunjuk..dan kemudian saya akan minta dia orang buat	Fariedah LC	Invalid Date
126	Teaching technique Concerned for students	contoh saya pernah ambik kursus Akta Bekalan Elektrik . Akta Bekalan Elektrik ini memang boring lah. Kalau kita straightforward je..dia memang full theory. Dan dia adalah..kita ajar Law semuanya. Students technology engineering ini kita nak ajar law...jadi macam mana nak buat. Jadi apa yang saya buat..pertama perbincangan. Dari segi itu, saya lebih suka buat group discussion. Even dalam online sendiri, saya suka buat..yang ini	Fariedah LC	Invalid Date

		bincang ini, kita interrupt ..ada dua way communication lah. Kalau saya ajar guna conventional, straightforward je..memang tidur.		
127	teaching includes real life situation STEM teaching pedagogy	Satu lagi..saya suka guna real world punya..kalau istilah nya, in real world..IRL..in real life…apa yang berlaku dalam real life. Contoh saya ada satu assessment tu. ..dipanggil case study. Saya akan minta dia pergi relate kan apa yang dia nampak dengan apa yang ada kaitan di law. Jadi in real life , saya suka buat macam tu. Jadi dia tahu, jika macam ini, macam mana..	Fariedah LC	Invalid Date
128	students' background	untuk pelajar-pelajar TVET ni..seboleh-bolehnya kita cuba nak relatekan dengan the real thing.	Fariedah LC	Invalid Date
129	Online teaching for theory + practical class	Online learning, pada pendapat peribadi saya lah yea. Saya tidak terkena dengan kursus yang 100% amali. Saya tidak terkena yang macam tu. Saya terkena yang 30% sahaja amali. Lebih kepada kursus-kursus yang berkaitan dengan teori litar.	Fariedah LC	Invalid Date
134	opinion on online teaching how to conduct online teaching used of video, internet, software	Masih boleh dibuat..dan masih mampu dibuat..contoh, kalau macam full theory tadi akta kan..saya proceed je guna discussion. Walaupun saya tidak dapat nak tunjuk in real life punya situation, jadi saya guna image-image yang saya dapat , video-video yang saya dapat di internet. Jadi saya tunjuk, kalau kisah dia macam ni, macam ni..Ini kalau untuk full theory macam akta tu. Kalau 30% yang ada amali itu, amali itu kebanyakkannya berasaskan ..saya tukar . Asasnya ada simulator , pelajar cucuk..cucuk..then dia akan dapat reading. Jadi saya tukar menjadi software. Jadi s	Fariedah LC	Invalid Date
135	Peer collaboration Top management support Video making in youtube	Tapi saya ambik initiative juga, untuk membantu program lah..Macam hari itu, ada kawan saya tanya…”macam mana yea , nak buat demonstration ni?”..yalah amali kena ada demonstration dahulu. Sebenarnya idea ini datang daripada pengarah lama saya, Dr Mahazani..pernah jadi pengarah Kuching rasanya, Masa saya dengan dia di Pasir Mas…dia dah boleh foresee..dia kata “ why not demonstration ni kita video kan?”. Mula-mula , saya macam..tak best lah, tak setuju. Kita cuba untuk resist . Bila	Fariedah LC	Invalid Date

		pandemic, ada benar apa yang dia cakap tu. Jadi saya juga ada buat demonstration guna youtube sebagai platform saya untuk saya tunjukkan macam mana saya nak buat, bentukkan wiring tersebut.		
136	Collaborate with friends to produce teaching video	Kebetulan saya duduk di Pasir Mas lagi, dan duduk di dalam. Jadi saya boleh buat lah. Students tidak ada. Dengan kawan-kawan pensyarah lain, initiative kami, kami buat.	Fariedah LC	Invalid Date

X4

Memo ID	Memo	Quote	Author	Date
137	Understanding of STEM as 4 disciplines	Kalau ikut pemahaman saya, STEM yang melibatkan Sains, Teknologi, Engineering dan Matematik, merangkumi semua course yang saya ajar atau macam mana?	Fariedah LC	Invalid Date
138	Project based learning	bila bagi projek , budak sendiri yang buat. Ada..macam di sini ada 7 software yang digunapakai.	Fariedah LC	Invalid Date
139	STEM implemented at school level	aya search juga...STEM digunapakai oleh anak-anak di sekolah rendah...ada STEM	Fariedah LC	Invalid Date
140	know STEM as an event created	di sekolah menengah mereka mewujudkan event untuk pengajaran STEM ..	Fariedah LC	Invalid Date
142		Saya adalah ex student IKM Lumut..tahun 1998-1999 untuk Lukisan Mekanikal, selama setahun setengah . Selesai sijil di IKM Lumut setahun setengah (11:34) saya further lagi dalam diploma dekat UNIKL MFI selama 3 tahun. Selepas 3 tahun di MFI, kira rezeki Tuhan nak bagi ..Alhamdulillah saya sambung dekat France buat degree selama 3 tahun. Rezeki ketika itu, MFI dia nak collaborate dengan France..trial and error. 4 batch sahaja UNIKL MFI yang ke sana.	Fariedah LC	Invalid Date
143		Saya adalah ex student IKM Lumut..tahun 1998-1999 untuk Lukisan Mekanikal, selama setahun setengah . Selesai sijil di IKM Lumut setahun setengah (11:34) saya further lagi dalam diploma dekat UNIKL MFI selama 3 tahun. Selepas 3 tahun di MFI, kira rezeki Tuhan nak bagi ..Alhamdulillah saya sambung dekat France buat degree selama 3 tahun. Rezeki ketika itu, MFI dia nak collaborate dengan France..trial and error. 4 batch sahaja UNIKL MFI yang ke sana.	Fariedah LC	Invalid Date

144	Education background - start with MARA technical student in Mechanical Drawing, diploma MFI, degree in France specialize in Machine Building Maintenance and Technology	Saya adalah ex student IKM Lumut..tahun 1998-1999 untuk Lukisan Mekanikal, selama setahun setengah . Selesai sijil di IKM Lumut setahun setengah (11:34) saya further lagi dalam diploma dekat UNIKL MFI selama 3 tahun. Selepas 3 tahun di MFI, kira rezeki Tuhan nak bagi ..Alhamdulillah saya sambung dekat France buat degree selama 3 tahun. Rezeki ketika itu, MFI dia nak collaborate dengan France..trial and error. 4 batch sahaja UNIKL MFI yang ke sana.	Fariedah LC	Invalid Date
145	Subject matter expert	Kalau dalam pengajaran, pada masa sekarang ni saya mengajar Lukisan Mekanikal dan Rekabentuk. Di Pasir Mas hari tu pun saya dalam bidang yang sama Lukisan dan Rekabentuk. Bila sampai ke IKM KL pun masih Lukisan dan Rekabentuk cuma nya beza di Pasir Mas dia adalah diploma yang pure mechnical cuma plus sikit sahaja software	Fariedah LC	Invalid Date
146	industrial experience	Dapat juga dengan industry dalam setahun setengah sebagai draft person	Fariedah LC	Invalid Date
147	Industrial experience basis for teaching	Semasa menjadi draft person tu hanya menggunakan autocad sahaja. Adalah elemen nya sebab sekarang ni autocad , every year version nya di upgrade. Semasa zaman belajar dulu lain dan bila di peringkat diploma dah lain..dan bila masa mengajar kita pula yang tertinggal daripada students..students lagi laju . Teori dia masih lagi tough , masih lagi mampu mengajar dengan students Konsep nya masih sama hanya version nya sahaja	Fariedah LC	Invalid Date
148	Service in KKTM/IKM	6 tahun lebih, dah berada di 2 pusat	Fariedah LC	Invalid Date
149	Nature of subject , theory based, theory and project conducted individually or grouping; full practical based CAD; teaching strategy based on nature of subject	Dua kursus ni teori..tapi yang satu lagi ni service maintenance and departmental ..ini subjek teori plus dengan projek. Budak akan buat sendiri by grouping atau individu. Subjek yang keseluruhan practical adalah subjek CAD Computer Aided Drawing, yang ini saya memang guna autocad untuk mengajar	Fariedah LC	Invalid Date

		pelajar semester 1. Satu lagi subjek core abilities, ini memang teori sepenuhnya. Macam subjek CAD ni, tidak lah bila saya masuk kelas budak terus buat latihan, akan ada short talk..maybe dalam setengah jam ataupun satu jam based on subtopic hari tu. Selepas daripada tu akan ada demonstration daripada saya. Selepas demonstration ..yang demonstration tu yang kita selalu bagi jobsheet. So kita demo satu exercise dan budak akan buat semula. Dan pada masa budak buat tu kita akan around, nak tengok ok ke tak . Kalau dah ok baru saya akan bagi exercise ataupun seterusnya kepada assignment lah.		
150		Kalau dalam keadaan sekarang ni pandemic pakai online , saya masih mengajar cara yang sama ..cara kaedah nya masih ada short talk dalam masa sejam atau setengah jam Then saya akan demo maksudnya saya sharing . Dan kalau ada masalah..pada masa yang sama dia orang kekangan nya adalah kena ada laptop dan Alhamdulillah semua pelajar ada laptop dan boleh mewujudkan software yang saya pakai . Cuma kadang-kadang laptop yang mereka ada tidak support dengan software yang kita nak	Fariedah LC	Invalid Date
151	ICT used in teaching	Software autocad	Fariedah LC	Invalid Date
152	Obtain technical support from technician	Dekat sini ada technician. Saya akan masukkan technician dalam group whatsapp. Katakan students tidak boleh nak install di kedai, technician dekat sini boleh bantu..yang ini saya memang tidak mahir. Saya tahu, bila saya bercakap dengan students, ada autocad dalam laptop yang boleh pakai	Fariedah LC	Invalid Date
153	Lack of hardware knowledge so technician support	Sebab kadang-kadang students..bila hang laptop ke, saya akan minta terus direct dengan technician . Saya hanya tahu sedikit sahaja. Contohnya saya tahu tidak perlu yang branded , processor yang dia orang nak masuk tu minimum berapa.	Fariedah LC	Invalid Date

154	Challenge face conduct practical class in online teaching	Semasa kelas online ni, sesi sharing daripada pelajar ni yang ambik masa lama. Sebab nak tengok satu-satu. Nak kata tahu 100% tidak sama macam face to face. Kalau face to face saya boleh pegang mouse dia.	Fariedah LC	Invalid Date
155	Seek peer assistance when facing problem	Kalau sesi sharing pun tidak boleh control juga, saya akan minta mereka hantar direct , saya akan sendiri akan troubleshoot apa problem. “ Puan saya dah cuba buat apa yang Puan ajar. Puan suruh buat tapi tidak jadi” Jadi saya akan minta dia orang hantar yang CAD sebenar tu , saya troubleshoot lah. Kalau saya tidak boleh, saya akan minta tolong kawan-kawan yang lain.	Fariedah LC	Invalid Date
156	Teams and Google classroom as ICT for online class	Guna Teams. Tahun lepas tidak guna Teams . Tahun lepas guna google classroom dan google meet. Teams baru semester ni digunapakai . Semua kelas lah pakai Teams.	Fariedah LC	Invalid Date
157	online assessment	saya wajibkan on camera semasa test.. Test pun saya buat secara online . Tetapi memang wajib on camera semasa berlangsung (35:13). Katakan kalau 3 jam praktikal untuk subjek CAD memang 3 jam kena on camera.	Fariedah LC	Invalid Date
158	Managing class	Kalau time kelas, bila students ada masalah dia akan terus share dan kita akan check lah. Kekadang ada problem begitu kritikal sebab sharing tidak berapa nampak pun ..nampak kecil sahaja. Students akan hantar dekat saya guna whatsapp guna CAD punya folder . Dia tidak boleh hantar pdf. Saya yang akan buka semula. Samada students hantar dekat whatsapp ataupun (	Fariedah LC	Invalid Date
159	online assessment	Teams yang melibatkan turn in saya guna assignment dan test dalam tu. Kalau yang exercise PM sahaja.	Fariedah LC	Invalid Date

160	STEM teaching involves the whole programme, syllabus	Ada..dia ikut sub topik. Macam subjek CAD ni dia bukan hanya belajar pada semester 1 . Semester 2 nanti semester 3 nanti..cuma silibus dia berbeza. Penggunaan software masih lagi sama. Kalau tengok pada semester 2 memang akan relate pada math. Sebab adanya melibatkan pengiraan dalam “fit limit and tolerance”. Kalau subjek CAD yang saya ajar dalam Geometrical construction. Sebab drawing ni bila kita bagi soalan , dia bukan sekadar melukis tanpa dimension. Jadi bila dimensi ni bila semester 1 itu adalah basic dimensi tapi dia orang akan berjumpa jugak dengan fit limit dan tolerance. Tapi fit limit and tolerance ni dia orang akan apply dalam subjek workshop semester 1. Maksudnya dia orang kena faham bila tengok dimension dan apply pada subjek workshop dan pada semester 2 nanti dia orang akan relate pada .	Fariedah LC	Invalid Date
161	SEM teaching embeded in designing using software	Betul . Dalam keadaan design..macam kami dekat sini hanya design . Di IKM KL ada program sijil pembuatan . So maksudnya bila kami design dan pembuatan nak buat . Salah design dia orang akan dapat dimension yang salah , salah lah dia orang fabricate.Masa design tu kena betul-betul dimensi berdasarkan kepada keperluan apabila nak fabricate. Yang sains tu yang nampak nya pada materials lah ..Pelajar yang keseluruhan yang menggunakan STEM ni pelajar yang semester 4 semester 5 . Sebab dia orang kena fully lukis dan working drawing dan detail drawing . Maksudnya bukan lukis yang semester 1 ni ada yang lukis basic-basic ..sikit..sikit. Dia tidak lukis keseluruhan komponen. Untuk semester 4 bukan setakat itu sahaja . Semester 4 di IKM KL melibatkan projek proposal . Semester 5 nanti ada FYP . So dekat situ students kena buat pemilihan sendiri produk, kena design dan kena tahu a-z penggunaan materials. So saya nampak semester 4 tapi	Fariedah LC	Invalid Date

		untuk subjek saya semester 1 tidak ada.		
162	STEM teaching incorporate analysis in fyp	Secara keseluruhan untuk STEM di IKM KL ni adalah di mana mereka diterapkan pada semeter 4 dan semester 5 . Semester 3 dah start, students belajar di semeter 2 fit limit and tolerance . Katakan nak buat wielding kena tahu symol , mariking kena letak di drawing. Katakan kalau lecturer kurang arif tentang materials . Sebab dia ada supervisor . Saya akan pegang pelajar semester 4 dan semester 5 jadi sv , maksudnya students akan pergi kepada lecturer yang professional yang berkaitan dengan materials untuk bertanya . Bila dia orang present nanti dia orang akan tahu bahan apa yang dia orang pakai untuk dia orang , Bukan setakat design, dia orang kena tahu bahan juga . Itu pada pelajar semester 5 yang akan buat FYP . Kalau dekat Pasir Mas, fyp bukan setakat design tapi dia orang kena fabricate sebab dia orang ada workshop sendiri . Tapi macam di sini, dia more kepada design sahaja. Dan satu lagi students boleh buat adalah analisis (45:37). Diorang boleh tau kalau letak beban , analisis untuk diorang punya design tu . Kalau letak beban diorang boleh tahu berapa kemampuan..crack dekat mana . Tu ada dalam analisis drawing software kartia semester 5	Fariedah LC	Invalid Date
163	STEM teaching occurs cross semester	Mula-mula tu sebab duduk dalam skop yang saya mengajar jadi tidak meluas tapi bila pn dah cakap tadi, nampak sebenarnya . Bukan pada semester 1 tapi pada semester 4 dan semester 5	Fariedah LC	Invalid Date
164	due to pandemic, start online teaching with online assessment quiziz	Kalau yang pandemic ni ..penggunaan quizizz. Sebab ada melibatkan teori juga. Ada short talk dalam sejam kelas bermula . Maksudnya sebab teori even pun subjek itu adalah praktikal tapi teori kena tough (stable) . Kalau teori tak tough diorang tak boleh nak draw. Walaupun students hebat dalam software pun tapi kalau teori dia kosong , memang tidak boleh	Fariedah LC	Invalid Date

		buat. Sebab dia ada syarat..nak lukis perlu ada standard dan kena follow dia punya standard. Kalau teori dia tidak tough, tidak boleh buat lah. Saya akan guna quizizz..semester ni baru start.		
165	Practical class uses video during online teaching	Serta kelas turut direkod dan jika students tidak datang , pelajar boleh tengok semula. Dan pada masa yang sama untuk subjek praktikal saya akan download video untuk diberikan..memang sangat perlu. Untuk setiap subtopik , dua tiga video saya akan uploadkan . Students boleh cari sebenarnya tapi banyak video dia tidak berkaitan sangat .macam saya cakap di awal tadi..autocad setiap tahun version nya berbeza-beza. Dia dah update the latest punya. Yang saya guna tu memang students akan gunapakai dan software ..katakan autocad 2021..2018 ke atas lebih kurang sama. So saya akan cari video yang betul-betul berkaitan. Contohnya saya mengajar tu, diorang boleh tengok semula video yang berkaitan tu untuk tolong semasa kelas online ni. Waktu face to face tidak pernah share pun video F: Sebab Pn buat demo Pn sendiri lah..	Fariedah LC	Invalid Date
166	use students as apprentice to assist other students	kalau kelas face to face ni ..dalam kelas dalam sebulan tu saya sudah boleh cater..dalam 18 orang pelajar siapa sebenarnya jadi pa..pembantu . Sebab ramai kan..akan ada 2, 3 orang pelajar yang boleh lah. Pelajar-pelajar yang ok akan bantu kawan-kawan lain	Fariedah LC	Invalid Date
167	struggling conducting online class esp practical class	.kalau sem lepas saya bagi 4. Saya struggle..dan saya rasa orang lain pun sama . Rasa down sebab kita tidak pernah melalui dan subjek praktikal lagi tu..	Fariedah LC	Invalid Date
168	ICT becomes storage for data and managing class esp TEAMS and google classroom	Betul..sangat-sangat membantu . Sebab satu lagi bagi saya penggunaan google classroom dan juga teams ni , semua benda yang saya bagi pada students dan students bagi pada	Fariedah LC	Invalid Date

		saya ..yang turn in tu, semua berada dalam satu platform. ..jadi apa-apa pun dikira sebagai storage. Sebelum ni saya simpan duduk kat mana..bila nak cari tidak jumpa. Saya tidak tahu saya type nama apa. Tapi sekarang ni apa-apa yang berkaitan..benda itu lah saya nampak. Teams ke google classroom ke..amat-amat membantu . Kalau sesi pengajaran selepas ini pun, saya boleh tarik sahaja daripada teams atau google classroom. Sebab saya ..semua dah saya letak masuk dalam tu. Sebab boleh guna google form dan boleh direct dapat markah daripada situ . Itu saya nampak sebagai pemudahcara.		
169	using outcome based learning	Kita akan tengok kepada objektif dan learning outcomes kepada students.	Fariedah LC	Invalid Date
170		macam yang hands on tu memang ada. Biasa digunakan . Bila sebut projek based learning tu ada dalam subjek cuma bukan pada subjek praktikal . Pada sem 4 dan sem 5 yang menggunapakai projek based learning. Memang students kena buat sendiri. Dan subjek yang saya sebut tadi adalah subjek sem 4	Fariedah LC	Invalid Date
171		Di pusat ini, ada 7 software dengan 6 lab. 6 lab yang digunapakai. Satu lab dengan 20 pc by sem. Satu lab satu sem. Contohnya sem 1 akan berada di lab 555 dan yang itu akan ada CAD. Naik sem 2 diorang akan berpindah lab dan dekat situ software yang digunapakai adalah software inventor dan autocad juga. Maksudnya bila diorang up sem..sem 2 sem 3 diorang akan upgrade lagi diorang punya software. Software jadi berbeza tapi basic autocad tu digunapakai sampai diorang keluar kerja nanti. Amat membantu..Kalau dekat program yang ada dekat saya ni, ada smart tv ..smartboard ada satu..Semua lab ada smart tv . Dah tak pakai projektor ..semua	Fariedah LC	Invalid Date

		menggunakan smart tv. Yang saya duduk ni adalah classroom dan classroom ada satu smart tv.		
172	ICT devices align with the syllabus and curriculum needs	Sepenuhnya. Kalau macam students ..di sini ada 7 software dan pelajar perlu belajar untuk cara nak plot . Mesin plotter ada 3 kalau tidak silap saya . Dan boleh plot sampai saiz OA paper . Students kena tahu macam mana nak guna sebab segala assessment..bukan online lah ni..face to face . Memang students kena print sendiri semua assignment dan test dan final. Final tu memang satu hari. Pagi dekat depan pc dan kiranya dalam sejam untuk diorang plot.	Fariedah LC	Invalid Date
173	peer collaboration and traning provided to support ICT use	Untuk google classroom sem lepas tidak ada. Memang kena search sendiri dan bantuan daripada kawan-kawan. Memang kawankawan banyak membantu. Sebab tidak pandai pakai. Untuk teams ni memang sepenuhnya. Maksudnya sepanjang perjalanan teams ni memang ada kursus. Last kursus dengan teams dan onenote adalah tahun lepas.	Fariedah LC	Invalid Date

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Memo ID	Memo	Quote	Author	Date
174	STEM discipline expert	Graduate under bachelor engineering dalam bahagian electrical and electronic engineering di ums pada tahun 2000. Lepas tu saya further study dalam bahagian master dekat utm under master in engineering and electrical mechatronic and automatic control .	Fariedah LC	Invalid Date
175	Industrial experience	Sebelum tu saya bekerja di bahagian industry. First job saya adalah sebagai CAD CAM engineer	Fariedah LC	Invalid Date
176	Industrial experience	Saya beralih ke Testing Engineer ..yang ini lebih kepada buat IC..ST microelectronics dekat Muar dari bulan 5, 2005 hingga 2007.	Fariedah LC	Invalid Date
177	pedagogy training	Dekat Ciast..2010. Saya masuk 2008..then saya kena sah jawatan dulu ...lepas tu buat pedagogy selama 3 bulan tidak silap saya ..attachment dekat Ciast...2010	Fariedah LC	Invalid Date
178	Online teaching TEAMS	Kalau pandemic ni , semua pengajaran kita buat secara online . Untuk kelas sebelum ni saya mengajar Science dan technology . Kita menggunakan platform Microsoft teams	Fariedah LC	Invalid Date
179	Online teaching GC	api sebelum tu, sebelum enforcement mengatakan kita menggunakan Teams, kita dah gunakan Google Classroom.	Fariedah LC	Invalid Date
180	Organization input	ebab kita subscribe Microsoft punya so terpaksa lah kita gunakan sepenuhnya Teams punya tu kan . Platformnya sama sahaja, lebih kurang sahaja..macam tu.	Fariedah LC	Invalid Date
181	Nature of subject theory + practical	Combination ..ia macam sensor, kita kena buat satu system, kita kena buat programming , sambung sensor ..kena build circuit	Fariedah LC	Invalid Date
182	Class preparation	Kita ikut kita punya silibus ..pakai slides..then all the materials kita akan part dekat ..upload dekat Teams punya platform. Nanti students boleh tengok bila-bila masa and during the class kita boleh share. Macam yang tadi saya share tu kan..macam tu je la.	Fariedah LC	Invalid Date
183	Class management	Ok, Cuma kadang-kadang response daripada students tu ..kalau kita ada dalam	Fariedah	Invalid

		20 orang, tidak semua participate. Kita tidak tahu, walaupun dia ada masuk, dia ada di depan laptop ..nak kawal semua tu.	LC	Date
184		Video saya tidak buat. Kalau ada pun, saya ambik dari youtube dan share sahaja . Bagi link sahaja atau during the class saya mainkan sahaja video tu, tengok macam mana...ikut kesesuaian.	Fariedah LC	Invalid Date
185	Teaching strategy for practical class	Untuk practical , oleh sebab kita buat programming , kita akan share screen. Kita akan minta students install software tu dekat laptop diorang sendiri , waktu nak buat programming tu saya akan tunjuk macam mana nak buat..ia sama sahaja dengan teori tadi . Cuma kalau kita nak tengok students punya kerja kita minta dia share dia punya parts tu pulak. Bukan saya share sahaja bahagian saya punya. Saya stop then dia share bahagian dia pulak.	Fariedah LC	Invalid Date
186	Constrain conduct practical in online platform	Tapi kalau dari segi penyambungan circuit tu tak boleh lah..terpaksa diorang ambil video dan hantar kepada saya. Takut sambungan dia salah ke atau apa ke . Susah kita nak tengok juga kan	Fariedah LC	Invalid Date
187	STEM teaching	Arduino . Begini lah bila kita guna software Arduino ..kita akan beritahu dekat sini apa benda . Ini adalah sensor untuk measure humidity and temperature. Macam mana dia nak test dia punya program ni dia kena construct dia punya circuit and then connect to laptop dia and then baru dia compile and run . Kalau nak tengok program ni, ada output atau tidak .	Fariedah LC	Invalid Date
188	class management	So, En guna Teams, so recorded la kelas ni? N: Ya semua recorded.	Fariedah LC	Invalid Date
189		So, En guna Teams, so recorded la kelas ni? N: Ya semua recorded. F: Itu yang best guna Teams kan En	Fariedah LC	Invalid Date

		N: Ya, kita boleh rewind balik..mana yang kita tertinggal ke apa kan		
190	online assessment	Once kita dah record, dia tidak hilang mana pun kan . Kalau nak buat penilaian, kita boleh sahaja nak buat online . Cuma dari segi hands-on itu sahaja agak susah sikit	Fariedah LC	Invalid Date
191	Online assessment advantage	Untuk teori kita akan bagi..macam dekat Teams, kita boleh set masa semua ..bila dia submit. Kalau sebelum ni, dia hantar secara copy tu, kita pun tidak tahu, dia hantar on time atau tidak . Kekadang masuk dalam kita punya box pun kita pun tidak tahu . Kalau secara digital kita tahu..oo dia lambat . Kita tahu students mana yang hantar lambat ..kita dah set Tarikh semua . So kita boleh Nampak siapa yang submit lambat	Fariedah LC	Invalid Date
192	Peer collaboration	Dengan colleague . Mula-mula tu tiba-tiba sahaja kena guna kan . Kita pun dah tua dan kena explore macam-macam ..Tapi ok je	Fariedah LC	Invalid Date
193	ICT training	Dekat pusat tidak ada saya rasa, tapi HQ MARA ada	Fariedah LC	Invalid Date
194	peer collaboration	Discussion dengan colleague, kalau kita tidak tahu apa...dengan colleague la , sambil explore sendiri	Fariedah LC	Invalid Date
195	need time for ICT knowledge	Perlu masa ..kalau dalam waktu yang sempit tu susah juga la kan ..kita perlukan masa.	Fariedah LC	Invalid Date
196	opinion on STEM as disciplines	Pernah dengar..science technology..yang itu ke?	Fariedah LC	Invalid Date
197	STEM teaching example with software and calculation	Sekejap saya buka ya. (Share slides pengajaran Sensor Characteristics). Yang calculation tu tidak ada sebab saya minta dia orang scan dalam ni (tunjuk code scanner). Memang ada pengiraan, Cuma tidak ada dalam slide saya. Tidak jumpa pulak dalam waktu-waktu begini.	Fariedah LC	Invalid Date
198	ICT used align with SPMa element	So, saya guna sepenuhnya la kot. Sebab dari segi ..kalau sebelum ini kalau saya ada..saya tidak pasti matematik . Macam kalau kita ada sample of data and set of measurement ..ada 10 katakan . Dan kita nak plot. Kalau kita guna excel , kita boleh plot graf terus . Kita tidak adalah nak buat manual .	Fariedah LC	Invalid Date
199	Class management	Sebab secara online, walaupun budak boleh buka camera dan kita boleh tengok semua tapi kita tidak tahu focus nya macam mana. Nak monitor dia punya kerja	Fariedah LC	Invalid Date

		tu pun macam mana nak kata ya ..susahkan sikit la kot. Tapi kebaikkannya kita boleh record . Kalau tidak faham, dia boleh ulang balik , macam tu lah.		
200		Ia banyak save masa dekat situ lah kan. N: Ya. Kalau face to face, kelas itu habis..terus habis sahaja. Kalau tidak tahu, kena explore sendiri. Kalau online ni, bila ada recording kita boleh tengok balik video tu. Tahap setiap pelajar ini tidak sama. Mungkin ada orang itu fast learner , ada yang slow sikit.	Fariedah LC	Invalid Date
201	organization support - financial, provide training	Saya rasa daripada segi support dari management tu , tidak ada masalah. Samada dari segi training atau dari segi kemudahan . Semua tu ok tidak ada masalah. Kalau tidak tahu, Bahagian sumber manusia ..kita boleh terang dan boleh propose apa yang kita perlukan . Cuma facilities untuk pelajar ..pencapaian internet untuk staf ini tidak ada masalah. Tapi untuk pelajar.. untuk kita , open untuk kita explore apa-apa .	Fariedah LC	Invalid Date
202	Assessment	Kalau question paper itu memang kita akan upload dekat Teams lah . Kalau ada pelajar nak hantar secara personal, dia akan message secara whatsapp lah atau guna telegram macam tu . Memang kita ada create class sendiri . Kekadang kalau kita panggil dalam online class, ada yang tidak dengar . So kena ada whatsapp juga.	Fariedah LC	Invalid Date
203	learning becomes 2 way with students	Saya tidak cakap saya amat dominance...tapi kita share . Ada benda yang diorang bagitau . Kalau bab-bab video ni diorang memang hebat , dengan handphone	Fariedah LC	Invalid Date

X6

Memo ID	Memo	Quote	Author	Date
204	STEM education background	belajar di Pusat Pembangunan Kemahiran Sarawak (PPKS), dekat Tabuan Jaya selama satu tahun. Lepas tu sambung HND dekat BMI , selama 2 tahun setengah. Habis dah di BMI graduate dengan Higher National Diploma Electrical and Electronic Engineering pada penghujung 2003	Fariedah LC	Invalid Date
205		belajar di Pusat Pembangunan Kemahiran Sarawak (PPKS), dekat Tabuan Jaya selama satu tahun. Lepas tu sambung HND dekat BMI , selama 2 tahun setengah. Habis dah di BMI graduate dengan Higher National Diploma Electrical and Electronic Engineering pada penghujung 2003. Start bekerja 2004 di bidang engineering sebagai technician di Shah Alam, bermula 2004 bulan Feb sehingga pertengahan Ogos 2004. Pada 16hb, 2004 saya ditawarkan menjadi pengajar IKM.	Fariedah LC	Invalid Date
206	pedagogy training	saya kena menghadiri pedagogi dahulu, bermula 16hb hingga penghujung tahun 31 Disember.	Fariedah LC	Invalid Date
207	STEM teaching training	Di GMI juga , kelas teori dan praktikal. Lepas tu, kami attend up grading skill di IKM Lumut selama 3 minggu	Fariedah LC	Invalid Date
208	STEM knowledge background	Apa yang saya belajar di BMI, lebih kepada bidang elektrikal, wiring sedikit sahaja. Lebih kepada motor electrical dan PLC lah.	Fariedah LC	Invalid Date
209	industrial experience-troubleshooting	Sebagai technician, saya akan mengajar satu site , contoh nya ..operator ada mesin-mesin. Mesin tu guna motor , itu yang saya maintain . Kalau ada sensor yang ada masalah, saya akan check dekat monitor. Mungkin sensor ada masalah motor atau wiring. Dan jika ada lampu yang tidak hidup, saya akan turun dan check serta tukar apa yang patut. Ada setengah instrument yang rosak, saya akan tukar yang baru dahulu...kapasitor atau resistance ka. Lebih kepada repairrepaiar lah..	Fariedah LC	Invalid Date
210	TVET Educator that upgrade	Tapi apabila sudah menjadi pengajar MARA, ok lah..lagi seronok..Banyak	Fariedah	Invalid

	skill	yang saya dapat pelajari..upgrade kita punya skill , knowledge.	LC	Date
211	Upgrade knowledge and skill in MARA	Banyak yang saya dah upgrade dalam MARA ni. Dulu belajar pendawaian PW4 , ambik computer I1. Tahun 2015, IKM KK buat Latihan solar , saya pun upgrade ke solar competency.	Fariedah LC	Invalid Date
212	opinion on STEM teaching	Apa yang saya faham STEM tu bidang sains, teknologi, engineering and mathematics..	Fariedah LC	Invalid Date
213	ICT in STEM teaching	saya pakai hands-on sebab saya ajar electrical drawing, guna software autocad. Pakai makmal computer dengan perisian autocad lah.	Fariedah LC	Invalid Date
214		Ya, online teaching. Cumanya tidak ramai students yang ada computer dengan perisian autocad. Jadi pelajar hanya tengok macam dibuat menggunakan autocad. Saya terangkan apa yang perlu pakai autocad dan kepentingan	Fariedah LC	Invalid Date
215	affordances using autocad	Yang bagusnya guna autocad ni, dia simpan benda tu dalam softcopy. In the future..maybe sekarang ni drawing tidak banyak, nanti kalau ada yang baru, kita boleh edit sahaja...dan simpannya pun senang. Kalau dulu kita pakai kertas, susah kita mau tambah. Kalau nak tambah, kena lulus baru so banyak kerja.	Fariedah LC	Invalid Date
216	Online teaching using TEAMS	Saya memang guna Teams lah. Di dalam IKM, pelajar dah di daftar dengan email teams..teams app nya pun banyak. Macam-macam boleh buat..ada onedrive, boleh buat form..itu semua lah	Fariedah LC	Invalid Date
217		Online class tidak sama macam kelas biasa. Kena inform awal bila kelas dibuat...remind dan dimasukkan dalam calendar dalam teams. Lepas tu kena update juga dalam whatsapp group. Contoh kelas start pukul 2 kan..kita kan check students yang dah masuk dan belum masuk . Lepas semua dah masuk, kita akan tanya apa khabar semua. Untuk attendance, just download sahaja. Dalam teams, masuk dalam excel lah. Baru start, beritahu tajuk hari ni , objektifnya , learning outcomen	Fariedah LC	Invalid Date

218	Practical autocad conduct in the centre	Tunggu pelajar masuk IKM. Bila pelajar masuk sini, mereka buat drawing dan penilaian terus.	Fariedah LC	Invalid Date
219	constraint to conduct hands-on activity in online platform	Ada setengah pelajar tidak Nampak sebab mereka hanya membayangkan sahaja. Balik-balik students tanya bila kita boleh masuk IKM dan kita ..hands on macam tu..	Fariedah LC	Invalid Date
220	online class management	Kadang-kadang macam ni, pelajar join masuk..lepas tu keluar..then join balik.Sebab masalah internet dan data. Bila kita download attendance, akan Nampak students keluar masuk.	Fariedah LC	Invalid Date
221	way to get students' respone	Kadang-kadang saya tanya on the spot.	Fariedah LC	Invalid Date
222	assessment f2f	Penilaian akan minta pelajar melukis lah	Fariedah LC	Invalid Date
223	emphasis on students' outcome	Kalau ada pun, satu dua pelajar sahaja. So IKM consider pelajar perlu hadir lah. Objective dia pun students should be able to draw. Maksudnya pelajar mesti boleh melukis dan menghasilkan lukisan. Students' outcome lah	Fariedah LC	Invalid Date
224	theory class	Yang saya upload untuk lesson plan dan recording class ya adalah akta lah. Akta adalah untuk sem 1 dan sem 6. Akta memang fully theory	Fariedah LC	Invalid Date
225		Saya guna slides dalam bentuk point dan rujuk kepada buku akta. Contohnya akta 24, akan minta students rujuk buku akta. Dan pada penghujung saya akan ada sesi soal jawab. Saya akan bincang soalan serta jawapan. Buku akta, pada awal semester saya dah minta students order dekat shoppe..harga dalam RM17, kalau free postage. Tapi kalau ada postage dalam RM18 ke RM19. Kalau beli dekat kedai di sini, dalam RM25...mahal.	Fariedah LC	Invalid Date
226	online assessment using Teams or GF	Saya akan guna Microsoft form...google form. Ada setengah ya saya guna Microsoft form, yang dekat teams. Cuma Microsoft form, ada students tidak ingat password untuk access teams, tu menjadi susah sikit. Tu yang pegi ke google form.	Fariedah LC	Invalid Date
227	technique online assessment,	Sebab jawapan agak Panjang. So saya minta pelajar tulis di atas kertas	Fariedah	Invalid

	consider students' constraint	kajang dan upload di dalam google form juga. Kalau guna format paragraph, sebab jawapan Panjang...ada akta apa dan section apa. So kalau pelajar guna laptop boleh lah taip Panjang tapi kalau guna handphone agak sukar . So saya minta pelajar tulis atas kertas, snap dan upload lah	LC	Date
228	ICT in STEM teaching	Pengiraan nya melibatkan ..contoh jika pelajar melukis satu objek, melibatkan gambarajah dan ukuran-ukuran . Setengah ukuran itu perlu dikira juga . Contohnya untuk melukis objek dan lukisan adalah sama...berapa Panjang dan lebarnya. Actually, yang banyak guna autocad ni sebelum elektrik adalah bidang mechanical. Saya sempat juga mengajar autocad untuk mechanical di JB..pelajar Marin lah. Tapi lukisan lebih kepada isometri dan 2d...pandangan atas, pandangan belakang. Lagi rumit dibandingkan dengan elektrik...lebih kepada pelan rumah,lukisan skimestik.. paling simple. Mencabarnya mengajar mechanical (30:49). Kekadang ukuran nya hidden dimension. Contoh diberi atas, di bawah tidak ada..so kita kena tengok samada di tambah atau ditolak. Baru dapat Lukis. Itu mechanical autocad.	Fariedah LC	Invalid Date
229	Before using software autocad	Sebelum tu kita pakai manual, lukisan tangan.	Fariedah LC	Invalid Date
230	self exploration using youtube	Tidak ada. Sebelum saya di JB mengajar mechanical ..memang belajar sendiri. Time tu 2008..2009..youtube pun belum banyak. Jadi saya pegi library, cari buku dan baca. Dan cuba buat. Macam tu lah saya belajar. Tidak ada cikgu...experience sendiri, explore sendiri.	Fariedah LC	Invalid Date
231	ICT devices in f2f and online classess	Kalau kelas fizikal, computer, software, lcd projector..letak di depan. Bila kita Lukis, kita pancar di belakang, dan students boleh Nampak. Macam mana nak Lukis line, circle..macam tu lah.	Fariedah LC	Invalid Date
232	past experience with technology device	Sebelum projector dulu kita pakai ..2007..2008..dah start pakai computer dan projector LCD. Sebelum tu, 2004..2005 belum pakai lagi., Sebab ikm masa tu ..lebih kepada pakai OHP, pakai transparency yang plastic..time JB dulu macam tu lah. Dari 2007, kita dah start guna lcd	Fariedah LC	Invalid Date

		projector dan laptop...lebih sedap di pakai berbanding OHP...tapi share-share juga lah. Kalau di KK ni banyak dah. Saya pindah sini pun 2010, so alat ICT nya pun dah banya		
233	pandemic ignites online teaching skill	Lebih-lebih bila dah start pandemic hari tu, kita dah boleh start mengajar dari rumah dan share semua..serta dapat semua maklumat melalui online ICT macam ni.	Fariedah LC	Invalid Date
234	lesson preparation	Video selalunya saya akan download dari youtube dan lepas tu saya share dengan students.	Fariedah LC	Invalid Date
235	affordances of ICT device used in STEM teaching	Impaknya memudahkan untuk kita menyampaikan pembelajaran serta menarik minat pelajar. Kita boleh sediakan powerpoint yang menarik lah..ada infografik berbanding dengan bila mula mengajar 2004 dahulu, hanya menulis di whiteboard. Kekadang kita menulis di depan, students dah boring di belakang. Bila dah ada alat ICT, kita guna powerpoint. Kita buat powerpoint yang ada infografik. Orang lebih suka melihat gambar berbanding dengan tulisan. Kalau banyak tulisan menjadi boring, so bila ada gambar kita bercerita lah.	Fariedah LC	Invalid Date
236	preparing teaching materials for online class	Penerimaan pelajar setakat ini..tidak ada juga sebarang complaints. Pelajar suka dengan kemudahan ICT ni. Untuk pengajar, cabaran dalam menyediakan bahan-bahan mengajarlah ..	Fariedah LC	Invalid Date
237	ppt suits for electrical engineering	Ya betul. Kalau mathematic lebih mudah guna whiteboard, sebab perlu menulis jalan kerja kan..Untuk electrical ni, menggunakan powerpoint lagi menarik lah sebenarnya	Fariedah LC	Invalid Date
238	affordances in ICT	Tapi kalau guna pad, dan kita tulis di atas dan kita terus pancar sahaja..	Fariedah LC	Invalid Date
239	organization support on preparing ICT devices for teaching in align with digitalization project	Kalau di IKM KK ni, dari segi ICT tidak ada masalah. Kebanyakan peralatannya yang baru. RMK12 hari tu mereka ada buat pembelian baru...serta set up untuk kelas pendigitalization.	Fariedah LC	Invalid Date
240	software version upgraded	Macam ni..kadang-kadang upgrade version autocad depends dengan pusat juga. Apa yang saya pakai sekarang pun kira baru juga..2016.	Fariedah LC	Invalid Date

		Kalau nak yang upgrade, computer pun kena upgrade juga. Dari apa yang saya tengok dari versi 2011 ke 2016..tidak juga banyak perubahan. Perubahan hanya lebih kepada untuk buat 3d		
241	software uses suits content of subject taught	Sudah memadai lah..Kalau 3 d ni lebih kepada lukisan orang mekanikal..kalau elektrikal tidak perlu sangat.	Fariedah LC	Invalid Date
242	training provided by centre with self exploration	Mula-mula dulu, memang ada diterangkan macam mana nak pakai , time je lah. Lepas itu saya explore sendiri..macam mana nak pakai itu..pakai breakroom..belajar sendiri sahaja. Kalau raguragu, buka sahaja youtube, macam mana nak buat.	Fariedah LC	Invalid Date
243		Setakat ini ok, Cuma masalah server internet dekat lab..kadang-kadang pelajar kena guna data sendiri..hotspot. Kalau saya minta pelajar mencari bahan rujukan akta, mereka terpaksa pakai hotspot sendiri. Kalau di computer..memang semua ada internet, Cuma server dah teruk. Ada juga pusat membuat kertas kerja untuk memohon server baru, tapi ditangguhkan..macam bajet tidak cukup.	Fariedah LC	Invalid Date

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Memo ID	Memo	Quote	Author	Date
244	STEM background	Assalamualaikum , nama saya Azizul Hasnim binti Bakri. Berasal dari Kuala Lumpur. Min dulu belajar, sekolah semua di KL, melanjutkan pelajaran yang first sekali selepas SPM ke IKM Lumut, dalam bidang senibina. Lepas tu Min masuk UTM ambik civil engineering diploma . Then ambik degree di UITM Shah Alam...lepas abis degree Min terus kerja..tapi tak lama. Sebab Min grad 2004 bulan 4. Lepas tu Min dapat kerja MARA bulan 4 2005.	Fariedah LC	Invalid Date
245		Assalamualaikum , nama saya Azizul Hasnim binti Bakri. Berasal dari Kuala Lumpur. Min dulu belajar, sekolah semua di KL, melanjutkan pelajaran yang first sekali selepas SPM ke IKM Lumut, dalam bidang senibina. Lepas tu Min masuk UTM ambik civil engineering diploma . Then ambik degree di UITM Shah Alam...lepas abis degree Min terus kerja..tapi tak lama. Sebab Min grad 2004 bulan 4. Lepas tu Min dapat kerja MARA bulan 4 2005. Ada setahun..tapi Min kerja 9..10 bulan begitu sahaja. Jadi site supervisor cum designer , sempat handle satu projek warehouse sahaja.	Fariedah LC	Invalid Date
246	industrial experience	api Min kerja 9..10 bulan begitu sahaja. Jadi site supervisor cum designer , sempat handle satu projek warehouse sahaja.	Fariedah LC	Invalid Date
247	STEM knowledge background	Masa mula di UITM ambil diploma dalam civil engineering, masuk tahun ke 2 Min berhenti sebab nak ambil arkitek dan dapat diploma architure di UITM..hujung 1998 tu dah masuk diploma senibina dan sambung degree senibina.	Fariedah LC	Invalid Date
248	STEM knowledge background	Lepas tu Min sambung master dalam 2014..2015 macam tu . Time master tu ambik education management. Lepas tu 2018 cadang nak ambik phd	Fariedah LC	Invalid Date
249	pedagogy training	Kami bukan dengan ciast tapi GMI..2005. Kalau ciast dah posting baru kena panggil pedagogi kan..kami yang kelas siang malam..pedagogi dulu baru posting	Fariedah LC	Invalid Date

250	STEM pedagogy	Kami ada 3 batch..batch pertama dipanggil upgrading skill dan kena pergi ke IKM Sg Petani. Batch kitorang batch kedua, pegi ke Bandung...dengan politeknik Bandung selama 2 bulan.	Fariedah LC	Invalid Date
251	industrial experience	Saya kerja dekat company Idaman Sdn Bhd. , dekat kpg pandan. Masa tu , dia memang cari site supervisor. Min kena jaga juga site even fresh graduate,dari zero iatu tanah terbiar, tanah lapang, naik daripada clearance..cut and..progress..sampai siap. Kira time Min berhenti tu memang finishing , tinggal nak serah pada owner sahaja. Masa tu dia bukan arkitek company tapi developer, maksudnya tidak perlu arkitek untuk design. Janji boleh kerja dan design dan tau selok belok elektrikal, piping..semua tu memang basic kita belajar. Bila kita pegi tu dia tidak panggil arkitek atau assistant arkitek , dia panggil site supervisor cum designer. Macam warehouse 4 segi sahaja..kita tahu apa requirement untuk buat warehouse. ..besar tingkap ke..basic-basic tu ada	Fariedah LC	Invalid Date
252	organization management	Kalau ikut subjek, kan kita orang tidak cukup staff, dan kita orang pun buat bcos, KJ, KP decide supaya kita tidak rombak kita punya kursus. Biasa kalau kursus kita pegang sepanjang PKP ni, memang jarang tukar. Kalau cerita berapa banyak subjek, maksimum ajar 5, tapi sem ni ajar 4 lah. Sem ni dan sem lepas, Mien maintain pegang 4. Sem ni dan sem lepas, Mien maintain pegang 4. Kalau kelas teori yang dua kredit hour, ada semester 1 dan semester 3. Sem 1 tu architure history, semester 3 architure practice.	Fariedah LC	Invalid Date
253		tapi kita kan online especially semester 1, untuk students semester 1, kita nak explore benda untuk dia. Contoh kita boleh cakap Chinese architure, Indian architure, kita boleh cakap, tapi dia hanya tahu Chinese, Indian itu bangsa. Dia tidak boleh nak decide, apa benda	Fariedah LC	Invalid Date
254	giving task to students using ICT	Aaa kaedah yang Mien gunakan kalau untuk benda yang students baru berkenalan dengan bidang ni kebanyakan Mien gunakan kaedah search internet	Fariedah LC	Invalid Date
255	digital online teaching materials preparation	Biasanya Mien akan buat slide, satu unit itu kita ambil 2, 3 minggu kan. Kita bahagi-bahagikan mengikut silibus yang bersesuaian. Berapa banyak gambar	Fariedah LC	Invalid Date

		yang Mien search dan tunjuk dekat students, sampai diorang boleh buka mata.		
256	teaching approach	Let's say Mien cakap pasal Islamic architecture, kalau Islamic architecture , orang tahu masjid sahaja. So Mein bagi contoh dekat student. 'Katalah saya bagi KLCC, adakah KLCC itu Islamic architecture?'. Kalau diorang cakap 'tak', sebab diorang bangunan tinggi, bangunan biasa, Mien akan bagitau lagi ' sebenarnya architect yang membuat design KLCC itu Namanya (), orang Australia. Adakah dia menghargai Malaysia sebagai negara Islam? Kita akan terfikir, kalau orang yang fresh, 'Takkan kot orang putih, patutnya Islam kan?' Masa itu lah kita boleh explore. Sebagai contoh, bagaimana kita tunjuk Islamic architecture. Biasanya 2 biji 4 segi dan dia rotate. Dan bila dia rotate dia akan jadi macam star. Star tu part of geometric Islamic architecture. Contohnya kita ambik kubah. KLCC itu ada (), macam minarate, Menara tu kan. Bila kita tunjuk, 'Oo diorang cakap itu islamic'(16:15) Mien cakap ' Tak, kalau ikut kubah tu bukan Islamic, kubah itu Indian.'. Dengan cara kita bagi tunjuk students dengan pelbagai gambar, kadang-kadang kita buat google maps..kita masuk dalam dan pegi ke India. Tapi since pkp ni, internet problem sikit . So Mien hanya dapat capture gambar, screen capture , crop cantik-cantik dan tunjuk diorang. Lepas tu contoh kalau benda dah tak ada, kita boleh cari gambar-gambar. Lepas tu cakap benda ni dah tak ada, dah runtuh. Itulah cara untuk history. Tapi kalau contoh amali teori autocad. Autocad kita ada kekangan di mana bukan semua students kita mampu untuk ada laptop sendiri. Jadi pendekatannya Mien akan ajar jugak ikut hours, ikut silibus, ikut sow, selain daripada tu, Mien buat youtube channel.	Fariedah LC	Invalid Date
257	ICT used	Contohnya hari ini Mien mengajar buat teta block . Mien akan buat satu video dan akan upload dekat youtube. So boleh lah diorang refer,	Fariedah LC	Invalid Date
258	using role play to create	Basic architecture design. Aaa yang ini critical sedikit lah. Benda ni dia ada	Fariedah	Invalid

	real life scenario, with constraint doing it online	grade session. Setiap kali students design, kita bagi dia satu role project . Bila dia design , akan present final. Bila dah siap baru dia present depan kawan-kawan. Tapi sebelum final tu kita ada grade session. Grade session tu macam discuss antara owner dengan customer, jadi sekarang ni Mien lah owner. Cara diorang, kalau dulu kita boleh lah menghadap depan-depan, conteng-conteng . Tapi disebabkan oleh keadaan sekarang ini, kita online. So kita hanya boleh buat through whatsapp sahaja	LC	Date
259	managing practical class in online mode	Kejap, kalau Mien dapat buka camera kejap. Teruk betul line dia. Aaa macam ni (tunjuk dalam handphone). Students akan hantar, dan Mien akan tegur mana yang patut. Tapi cara tegurannya pulak , selain Mien conteng, Mien akan hantar voice. Tapi cikgunya akan cakap lah. Ini boleh, ini tak boleh. So diorang boleh alert di mana diorang punya problem. Biasanya kalau kita akan dapat autocad , contohnya autocad , yang design atau subjek yang berkaitan dengan amali. Macam dua semester yang lepas, kita dapat 2 hingga 6 minggu untuk diorang final. Bila diorang datang, kita kena kejar abis lah. Ada yang kita kena ulang balik, ada yang kita boleh proceed terus, yang senang pick up, diorang boleh proceed terus, diorang faham apa yang kita nak. Selain itu kita buat video call, sampai tengah malam pun ada. Nasib students sikit, tapi kalau ramai susah sikit.	Fariedah LC	Invalid Date
260		Macam design tu, hands-on tu. Benda nya kena berturut, tidak boleh skip satu pun. Caranya , kalau budak kena buat presentation board. Kita pakai mounting board. Tapi alasan Puan , pkp Puan, kampung saya tidak jual. ‘ Kamu pakai sahaja, janji boleh Lukis.’ Impossible tidak ada pen sebatang dekat rumah kan. Yang mana ada computer boleh proceed dengan computer. Yang mana tidak ada computer, kita cuba lah bantu macam mana pun. Kalau nak tunggu masuk kak, katakan 4 minggu sahaja..	Fariedah LC	Invalid Date
261	assessment feature	Minimumkan lah mengikut AIF. Kalau dalam tu tak perlu present, tidak present, janji pelajar buat.	Fariedah LC	Invalid Date

262	view on STEM teaching	Technical..apa kita panggil Mathematics ke?	Fariedah LC	Invalid Date
263	STEM teaching differentiate according to level of students programme	Secara generally nya, architecture ni memang bidang sains. Dan mathematics itu adalah priority . Cuma bahagian sijil itu, kita kuranglah calculation itu, tapi ada satu topic semester 2 , architecture structure. Yang itu sahaja ada calculation. Macam contoh Mien, macam autocad , history, practice, memang tidak ada calculation lah . Dalam design ada sedikit tapi basic sahaja lah.Macam mana kita nak dapat satu area untuk satu bangunan, ini kali apa kali apa. Tapi yang itu dia guna buku by law. Cuma sekarang ini, level sijil, kita tidak tekan kan lagi STEM , dekat kita punya pdp.	Fariedah LC	Invalid Date
264	STEM teaching	Tidak detail. Itu yang Mien kata tadi, kita ada satu subjek di mana students betul-betul buat calculation on moment, sharing moment. Itu memang beutl-betul calculation. Iaitu structural. Kalau kakak ingat, Gadafi yang ajar dulu. Eh, Kak Azie. Sekarang ni memang jadi problem bila students kita bila matematik bukan syarat utama untuk masuk architecture. Kalau kita masuk U, matematik itu memang syarat utama...add maths.	Fariedah LC	Invalid Date
265	ICT used	Biasanya basic di sini, slides..guna powerpoint lah. Macam youtube tu, nak kata web , bukan web ka	Fariedah LC	Invalid Date
266	blog	Kalau sebelum zaman youtube ni, Mien guna blog. Tapi tak tahu lah..sebab lama dah tidak updatekan .	Fariedah LC	Invalid Date
267	ICT used	Kita ada autocad, sketch up, ada adobe. Adobe ada photoshop, ada illustrator.	Fariedah LC	Invalid Date
268		Kita ada autocad, sketch up, ada adobe. Adobe ada photoshop, ada illustrator. F: Oo ok. M: Dan sekarang ini, semua ini sudah di masuk kan dalam silibus F: Ooo silibus sijil ya? M: Yes. Semasa students semester 3. F: Kira heavy juga la M: Itu lah kita rasa kekangan apabila students tidak ada laptop.Contoh nya semester lepas dah masuk dah , seronok lah. Tiba-tiba students ada kes covid. Students tidak dapat masuk kelas.	Fariedah LC	Invalid Date
269	constraint students	emasa students semester 3. F: Kira heavy juga la M: Itu lah kita rasa kekangan apabila students tidak ada laptop.Contoh nya semester lepas dah	Fariedah LC	Invalid Date

		masuk dah , seronok lah. Tiba-tiba students ada kes covid. Students tidak dapat masuk kelas.		
270	students need	Semester 2 students kena ada laptop dah. Kalau dulu , sem 3 masih manual lagi. Sekarang, sem 2 dah total pakai laptop. Bila jadi macam ni, ia jadi problem sangat-sangat untuk kita orang.	Fariedah LC	Invalid Date
271	class management	macam 1st day tu , nak pegang mouse pun takut. Sampai kena buat lawak ' mouse tu kalau tekan dia menggigit tangan tu. Diorang pun explore technology . Students tidak pernah tau pasal autocad, buka autocad. Kalau hari first dah start dah buat (30:32), petang tu Insya Allah dah boleh,excited dah. Kalau students suka, diaorang akan explore.	Fariedah LC	Invalid Date
272	start using autocad	Nasib Mien sebab dari mula mengajar dah kena mengajar autocad.	Fariedah LC	Invalid Date
273	profesionally qualified with autocad skill	Bila kita dah start mengajar, biasanya hq BKT akan hantar kursus untuk sijil professional atau competent. So memang kalau kita dah dapat sijil tu, dapat tak dapat, mesti kena. Aaa tapi benda tu kak , biasanya dia hantar kita ada hours dia. 6 hari kalau tidak silap. Dan dia ada version yang kita kena ambil sijil. Kalau kita tengok autocad, dia ada banyak version. 2015 , setiap tahun dia ada upgrade. Tapi version yang betul adalah yang diiktiraf oleh Autodesk. Macam yang last Mien ambik 2015 punya. Dia pun test tu, walaupun kita dah guna autocad bertahun-tahun pun, tapi percaya tak, yang pegi test tak sampai separuh lulus. Kalau tidak lulus, dia bagi kita sijil penyertaan sahaja atau sijil kehadiran. Then kalau kita search dekat Autodesk punya website , senarai nama-nama yang dapat. Sebab lulus dia 85. Lepas tu agency luar boleh panggil kita ajar	Fariedah LC	Invalid Date
274	self exploring	Aaah. Nak tak nak kita kena explore. Macam kita lah kak, tak pernah terfikir akan online, tiba-tiba macam ni..nak tak nak kita explore	Fariedah LC	Invalid Date
275	ICT must align with CLO	mpak dia students kena tau dan kita kena tau. Outcome mesti dapat mencapai CLO kita	Fariedah LC	Invalid Date
276	self explore, class management, online	ositifnya untuk kita sebagai Pensyarah, dulu kita tidak berapa rajin nak explore, sekarang ni kita explore. Dulu bila kita ajar students, students depan	Fariedah LC	Invalid Date

	assessment, challenges	mata. So kalau budak tu tidur ke, kita Nampak. Sekarang ni, cabarannya kita kena positifkan sebenarnya. Contoh bila kita nak bagi assignment, kekadang diorang bukan dengar pun apa yang kita cakap. Ending nya bila kita dapat students' submission assessment tu, kita rasa ,itu adalah satu benda yang positif. Walaupun dia tidak concentrate dalam kelas online tu, tapi dia ada. Kalau dulu, students depan mata nak tanya kita pun malu-malu kan tapi dengan adanya pkp ni , diorang akan research sendiri. Sebab diorang tak buat macam mana nak tiru kawan diorang . Diorang pun bukannya grouping, kebanyakan assessment itu kan individu. Itu positif. Negatif nya pun sama. Kita kena terima hakikat yang students tidak 100% concentrate apa yang kita ajar. Kita pun ada masalah line, ni bagi off camera.		
277	develop autocad skill during practical	Autocad ni, mula-mula start kerja, kena bagi je sebab semua orang pandai buat autocad. Hakikatnya, pada masa kita belajar diploma sem 7 baru kita buat autocad. Dan sem 6 kita pegi practical. Akak bayangkan kita pegi practical dulu , lepas tu baru belajar autocad. Sebenarnya, tempat practical tu lah kita belajar benda tu. Masa saya zaman IKM dulu, ada subjek autocad, tapi berapa jam je tak silap saya. Masa tu pun release 2011, semua kena taip, tak ada ikon-ikon dekat atas. Semua taip je, kena hafal dia punya code. Bila dah pegi practical diploma degree tu , masa tu lah kita explore sendiri. Bila hq hantar kursus tu, macam nila tambah sahaja.	Fariedah LC	Invalid Date
278	training given by hq	Ya betul. Zaman saya belajar dulu ada photoshop. Tapi kitorang tidak diajar. Cumanya kita tengok dan explore. Macam sketch up, mana ada kelas, tak ada apa. Cari sendiri dekat youtube. Paksa macam tu. Tak ada kursus. Kekadang subjek dapat, kursus kemudian.3,4 tahun lepas tu hq bagi kursus.	Fariedah LC	Invalid Date
279	prepare own materials	Kalau ada modul satu hal, tapi modul pun tidak ada kadang-kadang. Ada subtopik daripada silibus dia, itu yang kita search dia.	Fariedah LC	Invalid Date
280	peer collaboration	So far, yang lain boleh ajar. Tapi ..macam kalau ada yang terhilang ikon, ada setengah tidak tahu nak buat macam mana. Kadang-kadang kita buat sharing	Fariedah LC	Invalid Date
281	support from organization but quality	Mungkin ada lah. Contohnya macam pinjaman pembelian computer riba tu kan. Kebetulan kan Mien belajar, so benda-benda tu semua ada. Susah sikit	Fariedah LC	Invalid Date

	of devices	lah..sekarang ni organisasi bagi basic lapto		
282	digitalization program	Mien bahagian beam..bangunan punya. Setiap jabatan satu wakil. Ini tahun kedua. Last discussion pasal kursus. Kursus tu pasal beam. Beam tu adalah satu software yang baru.	Fariedah LC	Invalid Date
283	training	Kita cari sendiri. Bulan 5, Mien kena SLI beam juga. Selama sekurang-kurang 1 bulan. Maksimum 3 bulan	Fariedah LC	Invalid Date
284	curriculum	a, dalam beam tu ada banyak cabang-cabang lain. F: Cuma di pusat dia akan jadi satu subjek la kan. M: Cadangannya bangunan nak jadi ke diploma. Jadi beam ini akan jadi salah satu kursus yang wajib.	Fariedah LC	Invalid Date
285	organization information	Awalnya dia akan buat kompetensi dahulu. Untuk dapat mqa tahu lah prosesnya kan. Itu yang kita kena tengok staf dia. Qualification lah. Kalau kat sini out lah. Sapa yang sesuai. Caranya ini inisiatif dari organisasi, hantarlah kita pegi kursus.	Fariedah LC	Invalid Date
286	upgrade own skill	Yalah. Untuk ajar diploma at least degree. Untuk yang kompetent tu kita boleh ambik yang sijil-sijil. Kadang students kalau kita ajar, lagi bijak soalan dia.	Fariedah LC	Invalid Date
287	peer sharing	abatan bangunan ada 3 lab, senibina ada 2 lab.(45:39). Satu lab tu memang senibina punya. Zaman-zaman awal , semua autocad diajar oleh orang senibina. Mien ada ajar automotive, ajar aircond. Tapi sekarang dah tak ajar lagi, kita dah ada buat PSH, ajar antara staf, ..3L. Mien buat kursus untuk Pensyarah-pensyarah lain. Sampai Sahi pun dah pandai.	Fariedah LC	Invalid Date
288		Kalau kita ajar command tu biasa..buat line..buat circle. Kalau students Mien, diorang belajar buat pelan lantai. Kalau ajar students automotive, tak kan tiba-tiba buat pelan lantai. Satu masalah juga lah.	Fariedah LC	Invalid Date

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Memo ID	Memo	Quote	Author	Date
289	STEM knowledge	Baru sahaja tamat belajar dalam bidang Sarjana bidang elektrik kuasa di Universiti Teknologi Malaysia Johor Bahru dalam bulan Ogos 2021. And then ijazah sarjana muda elektrik di UITM Shah Alam majoring dalam instrument dalam Disember 2009, diploma kejuruteraan elektrik elektronik tamat pada Jun 2005 di UITM Samarahan Kuching Sarawak.	Fariedah LC	Invalid Date
290	experience not in related field	Lepas saya abis study dekat UITM degree , saya adalah sebagai RA research assistant di Fakulti akaun. Walaupun saya di bidang elektrik , saya perlu organize dia punya conference untuk research di Fakulti perakaunan macam perakaunan punya bidang lah... dalam masa 6 bulan juga. Pada penghujung 2009 until sampai bulan 1..saya berhenti sebab gaji pun tidak seberapa..elaun yang saya terima pun tidak banyak juga rm600 macam tu. Lepas tu saya apply sebagai TM Customer Technical Help Desk, sebagai pegawai customer yang angkat telefon..'hello thank you for calling TM, what can I do to assist you?'..itu saya lah pada 2010 mula bekerja Februari sampai bulan 6..betul lah saya rasa.	Fariedah LC	Invalid Date
291	CIAST	sehingga dengan En Wan Jazlan, suruh pergi interview..time tengah kursus di CIAST..	Fariedah LC	Invalid Date
292	understanding on STEM teaching	STEM ini adalah sebenarnya KPM punya policy yang melibatkan Sains, Teknologi, Engineering dan Matematik. Bila kaitkan dengan MARA ini, dia ada banyak BPT dan TVETkan. Kalau MRSM dia synchronize dengan STEM , tapi TVET lain, tidak sama dengan STEM tapi ada juga elemenelemen di sana. Itu yang saya faham. Apa yang TVET amalkan dengan STEM. Maaf kalau tersalah lah.	Fariedah LC	Invalid Date
293	STEM teaching practices not obvious in TVET	Itu yang saya cuba kaitkan. Kita ada buat tapi kita tidak realize. Sebenarnya ada juga matching nya dengan STEM dalam TVET.	Fariedah LC	Invalid Date