Faculty of Cognitive Sciences and Human Development

ASSESSMENT OF PRIMARY SCHOOL SCIENCE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN SARAWAK

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ASSESSMENT OF PRIMARY SCHOOL SCIENCE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN SARAWAK

BASHELA CAROL ANAK ROGER

A dissertation submitted
in partial fulfilment of the requirements for the degree of
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The dissertation entitled **Assessment of Primary School Science Teachers' Technological Pedagogical Content Knowledge (TPACK) in Sarawak** was prepared by Bashela Carol Anak Roger and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfilment of the requirements for the degree of Master of Science (Learning Sciences).

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

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(DR. TAN KOCK WAH)

Date: _______________

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LIST OF ABBREVIATIONS

TK	Technological Knowledge
CK	Content Knowledge
PK	Pedagogical Knowledge
TCK	Technological Content Knowledge
PCK	Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
TPACK	Technological Pedagogical Content Knowledge
MOE	Ministry of Education
EDO	Education District Office

ABSTRACT

Technological pedagogical content knowledge (TPACK) is the knowledge required for effective technology integration in teaching. TPACK assessment is important for teachers to understand their level of knowledge of technology integration in teaching. Since there were not much research on TPACK in Malaysia, the researcher conducted this study that focused on primary school teachers in Sarawak. In this study, Sarawak primary Science teachers' TPACK was assessed through an online survey. The participants were selected randomly in Kuching and Bau districts in Sarawak. The data and its analysis revealed that the primary Science teachers in general had a positive perception of their understanding of TPACK. It is an indication that primary Science teachers in Sarawak perceived themselves as being able to teach with technology effectively. Geographical factors such as school location and demographic factor such as gender has no significant influence to Sarawak primary school Science teachers' TPACK. However, there was a significant difference between teaching experience with the teachers' TPACK. Regression analyses revealed that Technological Pedagogical Knowledge (TPK) made statistically significant unique contributions to Technological Pedagogical Content Knowledge (TPACK) thus it is recommended that educational establishment to organize professional development trainings that focus on the TPK elements of Science subject.

ABSTRAK

PENILAIAN PENGETAHUAN TEKNOLOGI PEDAGOGI DAN ISI KANDUNGAN (TPACK) BAGI GURU SAINS SEKOLAH RENDAH DI SARAWAK

Pengetahuan teknologi pedagogi dan isi kandungan (TPACK) merupakan pengetahuan yang diperlukan untuk integrasi teknologi dalam pengajaran secara efektif. Penilaian TPACK adalah penting untuk guru memahami tahap pengetahuan mereka dalam mengintegrasikan teknologi dalam pengajaran. Memandangkan terdapat kurang penyelidikan mengenai TPACK dijalankan di Malaysia, penyelidik menjalankan kajian ini dan berfokuskan kepada guru Sains sekolah rendah di Sarawak. Dalam kajian ini, TPACK guru Sains sekolah rendah dinilai menggunakan 'online survey'. Responden dipilih secara rawak di daerah Kuching dan Bau. Data kemudian dianalisiskan menggunakan ujian statistiks. Dapatan daripada kajian menunjukkan bahawa guru Sains sekolah rendah di Sarawak menmpunyai maklum balas positif mengenai penggunaan teknologi dalam pengajaran dan pembelajaran. Faktor geografi seperti lokasi sekolah dan juga faktor latar belakang seperti jantina tidak mempengaruhi tahap TPACK guru Sains. Namun, terdapat perbezaan di antara tahun pengalaman mengajar dan tahap TPACK guru. Analisis regrasi menunjukkan bahawa pengetahuan Teknologi dan Pedagogi (TPK) menyumbangkan kepada tahap TPACK guru Sains sekolah rendah di Sarawak. Oleh itu, pihak penganjur yang mengadakan program peningkatan professional harus memberi fokus terhadap elemen TPK bagi program peningkatan guru Sains.

CHAPTER ONE

INTRODUCTION

1.1 Chapter Overview

This chapter provides the background of study in terms of the importance aspects of the topic discussed that related to past studies and the development of key concepts related to the integration of technology in Malaysian education. This chapter also provide an introduction to the Technological Pedagogical Content Knowledge framework, highlight the problem statement, research objectives and the research questions that this research seeks to answer.

1.2 Background of Study

In the wake of Malaysia to emerge in becoming a full developed country by the year 2020, the Malaysian Education Ministry has placed paramount importance of technology integration and innovation in the education system to meet the requirements of the 21st century learning. As described by Niess (2005), the educational standard of 21st century features various communication and information tools which affected the lives of today's society. This era shows how fast development of knowledge and technology influences all the changes in society and individual behavior (Hixon & Buckenmeyer, 2009). Most modern learners have shown great interest and engagement in the usage of technology, either at home or in educational institutions, resulting numerous amazing opportunities for educators and schools to benefit from the technology integration in the classroom, as well as promoting effective teaching and learning.

The Malaysian MOE advocated that ICT and other technological tools has the potential to support effective classroom pedagogy. MOE has established various standards and initiative to execute the adoption and integration of technology in the classroom. In line to achieve Vision 2020, the government has made a huge investment to provide technology in schools throughout the nation in 2016/2017. A massive amount of 1Malaysia net books for computer labs and Huawei T1 tablets for teachers were supplied throughout all public schools to support the initiative of technology integration in education, carrying the hope that it will facilitate and improve the quality of education (Chai, Koh, & Tsai, 2010).

The rapid development of technology has challenged educational institutions to practice technology integration in enacting their pedagogical plans in the classroom (Kankaanranta, 2005). Teachers with good knowledge and skills creates a positive and effective learning environment, thus producing positive impact to learners. Effective teachers also demonstrate various teaching strategies and approaches in order to provide meaningful learning. As training and experience plays important role in the teaching profession, educational programme that offers professional developments, pedagogical courses, study seminars or field experiences also contributes to their foundations to become excellent educators. In Malaysian public schools, teachers are expected to constantly explore different ways of teaching approaches equipped with technology integration as encouraged by the MOE. Teachers are challenged to conceptualize the technological skills and knowledge in order to produce technology savvy society. Educators are encouraged to integrate technology in their classrooms to promote, improve and maximize students' learning as well as supporting the capacity of learners in engaging to lifelong learning, such as through self-directed or collaboration between peers or experts (Law & Yuen, 2006). The role of educators has changed as they are required to integrate new approaches and philosophies of their pedagogical plans in order to properly challenge and stimulate learners.

1.2.1 The Importance of Technology Integration in Education.

Technology integrated learning has often been synonyms with the Science and Mathematics subjects. In line with the requirement of the 21st century learning, technology has been incorporated into STEM subjects. In the past literature, provided with supporting evidence stated that technology can enhance students' understanding and achievements in their academics' study (Graham & Thomas, 2000). In Science education, technology has been advocated to facilitate the ability of higher order thinking skills (reasoning skills at higher cognitive levels), encourage constructivism approaches in classroom and scientific inquiry as well as promote active collaborative learning (Jimoyiannis, 2010). Kaldoudi et al. (2010) reported that communication among learners and their academics performance will improve when technology exists in their project-based collaboration. When technology is integrated into lessons, learners are expected to be more interested in the subjects as technology provides different opportunities to make teaching and learning more creative and enjoyable. For instance, delivering the content or knowledge through gamification, virtual field trips or using other online resources. In addition, technology encourage active participation in the learning process which was difficult to achieve in the conventional learning environment.

Technology use in teaching and learning also promotes better knowledge retention as it encourages active participation among learners. Teachers may use different forms of technology to experiment with and decide which works best for learners in terms of retaining their knowledge. In addition, technology also encourage individual learning. Every learner are unique because of different learning styles preferences and abilities. Technology provides opportunities for learners with different needs to obtain effective learning, including disabled individuals. Access to the Internet provide access to a broad range of resources to conduct research in different ways, which in turn can increase the engagement. Learners also have the opportunities to practice collaboration skills by getting involved in online activities such as collaborating with other students from around the world on forums or by sharing information on virtual learning environments.

By integrating technology in the classroom, both teachers and students can develop skills essential for the 21st century learning featuring the collaboration with others, problem solving, critical thinking, development of communication and leadership skills, and improvement of motivation and productivity. Furthermore, technology can help develop many practical skills such as creating presentations, differentiate reliable from unreliable sources on the Internet and maintaining proper online etiquette. With countless online resources, technology can help teachers to improve their teaching methods, as enhancement from the conventional ways of teaching and promote student's engagement. This, however come with the evidences that teachers have deficiency and facing difficulties in the use of technology in their teaching. The preparation of teachers in the educational uses of technology appears to be one of the main components in almost every improvement plan for educational reformation. Based on this, it is essential for teachers to understand their level and implementation of technological knowledge and skills into their teaching pedagogy and enriching the content of the subjects. Therefore, it is important for the teachers to assess their technological pedagogical content knowledge in order to be completely up to date and knowledgeable with the curriculum, thus produce students with greater understanding of the subjects they are studying.

1.2.2 Technological Pedagogical Content Knowledge (TPACK).

The idea of TPACK has emerged to become a theoretical framework for teachers. Mishra & Koehler (2006) stated that considerable interest has emerged around the structures of TPACK, concerning the three major components, which are technology, pedagogy, and content knowledge. The technological knowledge (TK) is about how to use technology and combine technology in teaching, as well as the understanding of tools that can be used in their teaching, such as mobile applications or games devices. Pedagogical knowledge (PK) refers to the art and practice of teaching in an interesting way for the students to learn. Pedagogy not only refers to the accuracy of knowledge but the effectiveness of the teaching on students' learning. Content knowledge (CK) is the teachers' knowledge about the subject matter to be taught. This knowledge would include knowledge of concepts, ideas, theories and frameworks (Koehler & Mishra, 2009).

TPACK framework offers effective technology integration in the classroom which explains on how teachers' understandings of technology, pedagogy, and the content knowledge can interact with one another to produce effective teaching. The TPACK framework serves as the theoretical aspects that represent how a teacher design and conduct technology-enhanced instruction in the classroom effectively (Mishra and Koehler, 2006), as well and its potential to evaluate teachers' performance in teaching with technology (Graham, 2011). Mishra and Koehler (2006) utilized three intersecting circles as Venn diagram in representing the technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK), in order to unveil how technology, pedagogy and content knowledge contributes as the factors integrated into the TPACK model. The proposed Venn diagram has encouraged successive research in confirming the model and the derived factors of TPACK empirically (Archambault & Crippen, 2009). Pedagogical content knowledge (PCK) involves transforming content in ways that makes it accessible to students, in which the knowledge can be comprehended and applied by the student. Technological content knowledge (TCK) is critical to effective teaching because it provides the understanding of the impact of technology on the practices and knowledge of a given discipline and it is important in developing appropriate technological tools for educational purposes. Next, technological pedagogical knowledge (TPK) is knowing how particular technologies can change teaching and learning when used in certain ways, providing a clear teaching purpose. However, the technological pedagogical content knowledge (TPACK) is the most important interaction among the types of knowledge as it create new ways of how teachers repurpose technologies in a way that makes them as effective learning tools and enhance students' learning.

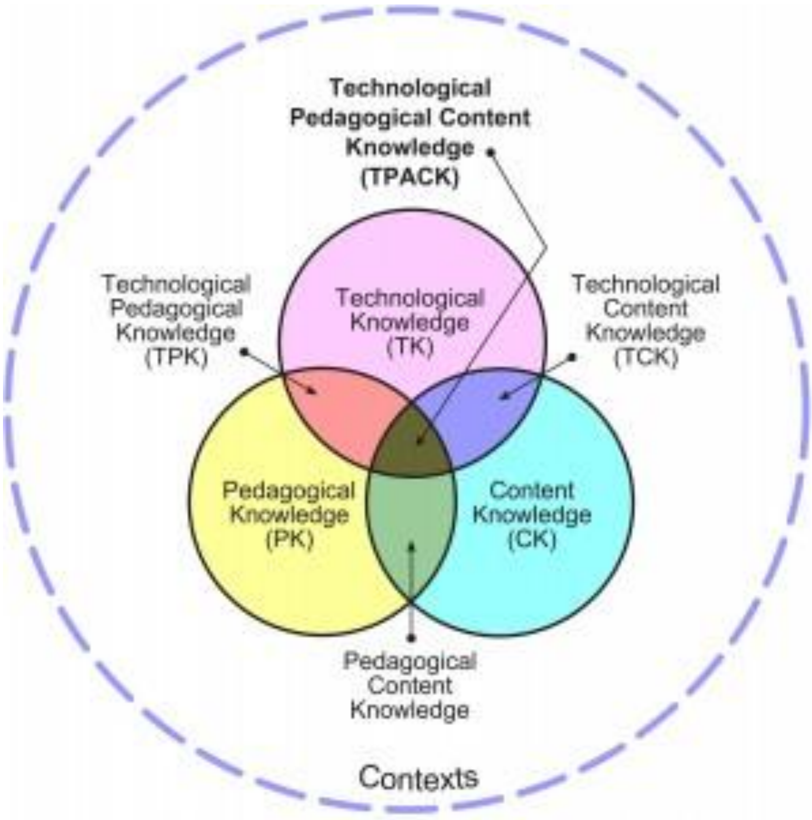

Figure 1.1 TPACK framework (Mishra & Koehler, 2006).

TPACK has become a much-discussed research topic in 21st century educational field and many researchers mutually agreed that TPACK provides appropriate framework that linked the gap between teacher education and educational technology. Most of the previous research have investigated teachers' TPACK with participants with a range of content background and have reported difficulties in substantiating the knowledge factors. This may imply the content-specific nature of TPACK and the importance to identify the TPACK constructs and factors precisely for teachers with similar academic background.

1.3 Problem Statement

Teachers with sufficient knowledge and skills create a positive environment for teaching and learning that will leave positive impacts on students. The implications of technology in education have been reported well in past studies (Lai & Pratt, 2008), which aroused the debate of whether technology should be integrated in the classroom (Valanides & Angeli, 2008) to how best to utilize technology in producing effective pedagogical enactments. Teachers are not only required to possess knowledge of specific technology but also the knowledge of how to adapt their strategies or teaching approaches with the use of technology to enhance learning process (Kereluik, Mishra, & Koehler, 2011).

The Malaysian MOE acknowledge the use of technology in classroom and recommended teachers to utilize technological tools in their teaching. To pursue the MOE's recommendation, teachers are encouraged to use technological tools to instigate interest and motivation of their students in learning the subject (Harlow & Cowie, 2010). However, there are arguments that teachers may have misconception on technology integration in their classroom as it is relatively known as a tool that have been repurposed to suit their teaching needs (Kereluik et al., 2011). Effective technology integration in education requires balance of technology, pedagogy and content knowledge (Angeli & Valanides, 2009). Harris and Hofer (2009) mentioned that teachers planning must consider the curriculum requirements, suitable pedagogical approach and the affordances and constraints of the available technology in their classroom instruction. Teachers should be able to choose appropriate tools to be used through the pedagogical plans to deliver content material which required knowledge for technology integration, specifically known as the technological pedagogical content knowledge (TPACK) by Mishra and Koehler (2009).

Though technology usage is recognized in Malaysian national schools, teachers need to develop a specialized knowledge of TPACK since the effectiveness relies on their pedagogical orientation in meeting the education goal of successful integration of technology (Webb, 2005). However, the literature indicates that there has been insufficient number of studies has been conducted on TPACK in East Malaysia, particularly in Sarawak (urban or rural area). The research studies available about TPACK in Malaysia schools are those conducted by Mohammed Yousef Mai and Mahizer Hamzah (2017) that looked on the development of an assessment instrument of TPACK for primary Science teachers, prioritized on the West Malaysia, whereas Nordin and Ariffin (2016) looked on the validation of a TPACK instrument in a Malaysian secondary school context, on which their study had small sample size and the TPACK study had not been assessed in a large scale due to the focus mainly on the Peninsula parts of Malaysia. Therefore, this study aim to assess primary Science teachers' TPACK in Sarawak (particularly in Kuching and Bau area).

1.4 Objectives of the Study

The objective of this research was to investigate the Technological Pedagogical Content Knowledge (TPACK) level of primary school Science teachers in Sarawak In accordance with the reviewed literature, the specific objectives of this paper was listed as follows:

a) To measure the primary school Science teachers' TPACK in Sarawak.

b) To investigate if primary school Science teachers' TPACK varies based on school location (urban and rural). To determine how demographic factor such as gender and teaching experience correlate with the primary school Science teachers' TPACK.

c) To determine the predictor of primary school Science teachers' TPACK in Sarawak.

In order to provide effective teaching and student learning that includes meaningful Science classroom experience and instructions, teachers need to understand the level of their TPACK development of the subject taught. The findings from this study also opens the consideration on the challenges and issues faced by the primary Science teachers in integration technology in classroom and possible solutions and recommendations to overcome the problems.

1.5 Research Questions

The research was carried out in order to answer the following research questions in meeting the research objectives:

1.5.1 Descriptive Research Questions:

1. What is the primary school Science teachers' TPACK in Sarawak?

1.5.2 Inferential Research Questions:

2. What are the primary school Science teachers' TPACK in the national urban and rural primary schools in Sarawak?
3. How does the primary school Science teachers' demographic characteristics such as gender and teaching experience interacts with their TPACK?

4. What is the major contributor to primary school Science teachers' TPACK in using technology in their classroom?

1.5.3 Research Hypotheses

The researcher have come out with several research hypotheses to be tested and proved along this study:

Hypothesis 1:

H_0 : There is no significant difference in primary school Science teachers' TPACK based on school location (urban or rural).

Hypothesis 2:

H_0 : There is no significant difference in primary school Science teachers' TPACK based on demographic characteristics (gender and teaching experience).

Hypothesis 3:

H_0 : There is at least one of the constructs contributing significantly to primary school Science teachers' TPACK.

1.6 Conceptual Framework

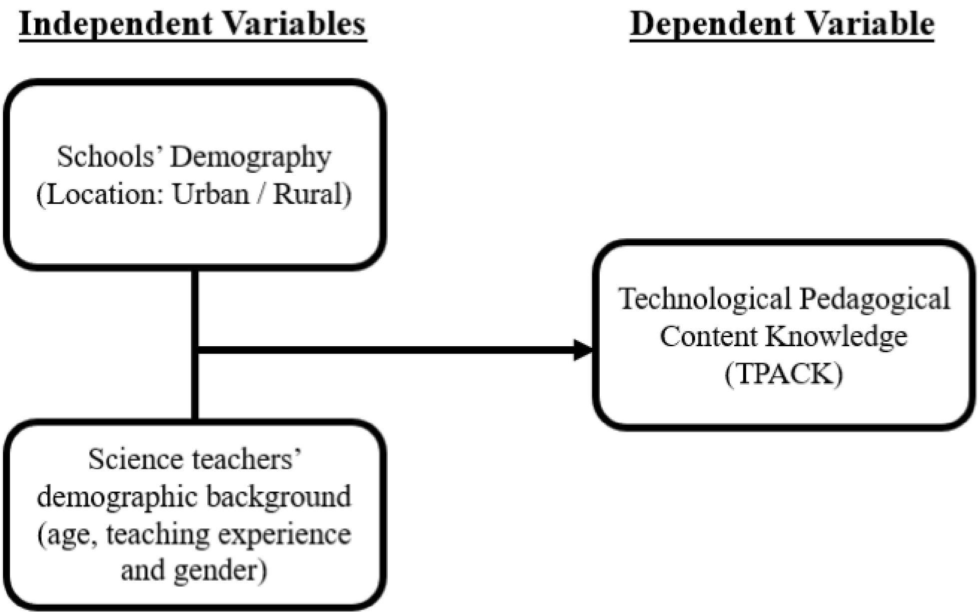

Figure 1.2 Conceptual Framework.

This study was done to assess the primary school Science teachers' technological pedagogical content knowledge (TPACK). The TPACK assessment was done using an online survey whose items were adapted from an already developed TPACK surveys by Mishra and Koehler (2006). The survey was sent to primary school Science teachers across Kuching and Bau area in order to measure how they perceived their understanding of technological knowledge along with the pedagogy and content knowledge in Science subject. This study also sought to seek if the primary school Science teachers' TPACK is influenced by their demographic factors or the types of school location. A multiple regression analysis was conducted to find out which of the constructs would be the major contributor to the primary school Science teachers' TPACK. Any professional development or learning for the participating respondents was not involved in this study. The research primary aim was to have a gain on the snapshots of primary school Science teachers' level of their technology use and knowledge in teaching, as well as to identify the factors that influenced their use of technology in teaching as technology integration was deemed feasible in different school types and levels (Jones, et al., 2003).

1.7 Significance of the Study

The findings from this research can be used to inform methods of support for primary school Science teachers in local context, specifically in Kuching and Bau area in Sarawak to deliver effective and meaningful learning to learners. This includes the affordances of technology integration in Science lesson. This research also provided information and awareness to both school committees and public about how well the technology being assimilated in teaching and learning process around the local context. Furthermore, this research also means to provide an insight into what impact of the increasing proportions of technology integrated classroom has on teachers and learners. In addition, this research can be used as reference or guide by other researchers which have similar area of interest, assisting other researchers to fully understand on the awareness of teachers on the elements of technology to be used in teaching and learning in national or private schools in Sarawak.

1.8 Limitation of Study

This study was conducted in Kuching and Bau area which does not cover the whole urban and rural schools in Sarawak due to limited time and resources to perform the study. The number of respondents who has completed the survey was 84. This considerable small sample size was probably due to the numbers of small in-service primary Science teachers, both in Kuching and Bau area and was not sufficient to predict or measure the TPACK of primary Science teachers in whole Sarawak. The results that were obtained were not sufficient to represent the technology integration in Science lesson in all schools in Sarawak.

1.9 Definition of Key Terms

The following terms and definitions are offered to clarify key constructs and how they are operationalized within the context of this study:

Integration of technology in education are the combination of pedagogical approaches and technology into teaching strategies to facilitate educational needs (Roblyer & Doering, 2013). In this study, this integration can be achieved when teachers understand the structures and types of the activity that are appropriate for teaching specific content of Science subject in primary school and the manners of technology usage as part of the lesson or in the classroom (Harris, Mishra, & Koehler, 2009).

Technological Pedagogical Content Knowledge (TPACK) is the knowledge required by teachers to integrate technology into their pedagogical plans enactment and content area that reflects their ability in teaching using the appropriate pedagogical approaches and technologies (Mishra and Koehler, 2006). TPACK framework as operationalized in this study representing the intersection of technology, pedagogy and content knowledge constructs which works as an instrument to measure primary school Science teachers' integration of the domains of content knowledge, pedagogical knowledge and technological knowledge (Schmidt et al., 2009).

1.10 Chapter Summary

The researcher reviews the importance of technology integration into the education system which have been one of the most crucial factors in meeting the standard requirement of 21st century education. Teachers need to have the urge of using technology incorporated teaching methods because of the modern learners and outcomes that demands it. The researcher also provides an overview of the research in the Problem Statement section after a brief expose of the Malaysian MOE's vision on technology integrated education in the

Background of Study, the benefits of the technology integration in education and a prelude to the Technological Pedagogical Content Knowledge (TPACK) framework throughout the introduction chapter. The Research Objectives stated the aim of this study, particularly focused on the primary school Science teachers TPACK and factors that influencing their level of TPACK. The Research Questions and Research Hypotheses formed the remaining sections of this introductory chapter in this paper. Although the benefits of technology have been well documented and modern teachers are using technology in their teaching, primary school Science teachers' TPACK in Malaysia has not been assessed on a large scale. The previous studies were focused on the development of the TPACK framework itself. The argument as provided in this chapter was that there have not been a deeper research that focused on the teachers' TPACK in the national schools, particularly in the districts of Sarawak. TPACK has been mooted as the essential knowledge that Science teachers should acquire if technology is to be integrated successfully into their teaching. Therefore, it is prudent to make the assessment of teachers' TPACK. The problem summarized might be useful for educators to understand how best to harness the increasing affordances and impacts that technology provides to education. These ideas have huge implications for how teachers perceive their role as educators and what should they consider to include in their pedagogical plans in order to achieve these educational aspirations.

Technology integration in schools is crucial to play role in assisting and improve the process of teaching and learning because it adds the fun elements in students' learning, which results in the need for educational establishments to discover the depth of knowledge on technology among teachers and their perceptions on technology integration in classroom activities. This study can help to spread the information on technology integration in local schools in Sarawak and factors affecting the level of teachers' TPACK within Sarawak schools.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter Overview

The purpose of this study was to identify the primary school Science teachers' TPACK and understanding on the usage of technology in teaching and learning based on the TPACK framework in the urban and rural primary schools in Sarawak. This study was also tp investigate the factors that influenced the Science teachers' use of technology such as the demographic characteristics (gender and teaching experience) and how they integrate technology in classroom. This review of related relevant literature encompassed the gaps in technology adoption in education, the influences of background settings and the relationship of demographic characteristics to TPACK, the various constructs of the TPACK framework including the predictor that contributes to teachers' TPACK, theoretical underpinnings of the model as well as how teachers' TPACK has been measured so far since the inception of the framework.

2.2 Technology Adoption in Education

2.2.1 Technology as Mindtool

Every aspect of human endeavour has been influenced by technology, therefore it is not surprising that technology has found its way into the educational system. Technology has greatly impacted how things are presented and taught in the classroom in terms of materials that are used and how these materials apply to enhance learning. We can see the result of technology surrounds us. For instance, materials such as textbooks and the Internet were invented and shows the result of the technology development in educational institutions setting. The prospects of using emerging and digital technologies to improve the teaching and learning process as well as students' academic performance have been noted by researchers (Lee, et al., 2009). These invented technological tools have a huge impact on students' learning and behaviour, as well as promote high cognitive skills. In these modern days, societies rely heavily on technology and the advancement of technology has change how individuals behave in their life (Hixon and Buckenmeyer, 2009).

There have been arguments in educational establishments that technology has the tendency to empower learners in developing thinking skills and enables them to do things that previous generation could not achieve due to the affordances of various technologies (Bolstad & Gilbert, 2006). Since technology is considered as mind tools, its integration in learning can promote learners to become a designer that is responsible for their own learning. Technology as mind tools empower the learners to think more meaningfully and to assume ownership of their knowledge, as well as their ability to apply those knowledges to solve problems in the real world rather than reproducing what the teacher have taught. Technology is termed as mindtools due to the interactive nature and the capability to process information when students learn with it (Jonassen, 1996). Jonassen (1996) also defines mindtools as "computer-based tools" and developed learning environments to function as intellectual partners with the learner in order to engage and facilitate higher order thinking skills.

2.2.2 Primary School Science Teachers' TPACK

Rapid development in computers, communication electronic and other multimedia tools furnish a broad range of sensory stimuli that helps learners to strengthen their understanding in various subjects in school. The animations, simulations, software packages that are available today build virtual realities and experience for the learners to engage in an active and joyful learning environment. Gulbahar and Guven (2008) reported that the integration of technology in teaching and learning can facilitate both teachers and students in improving and expand the quality of education by extending curricular support in difficult subject content areas. However, teachers and educators themselves would face struggles with the effective use of technology in their own courses. Although technological tools are provided in schools, teachers noted a distinct lack of integrated expertise in their institutions. Many studies show that the integration of technology in educational practice is a complex innovation for teachers (Voogt, 2009). Teachers have difficulty in integrating technology in their instructional processes. Therefore, even when the information and communications technology (ICT) applications have proven to be effective in isolation, this does not always imply that the same effects are also realised in natural educational settings (Olson, 2000).

Teachers need to repurpose the technological tool to fit their classroom learning environments as well as their learning objectives in order to derive maximum impact from the tool (Kereluik et al., 2011). Teachers needed to have a unified concept through which they can effectively integrate technology in their teaching. Learners today have grown up surrounded by technology and they already using technology in their informal endeavour which resulting in learners that process information differently from their predecessors (Prensky, 2001). Therefore, teachers cannot continue to teach them with conventional teaching methods but to adapt with the current needs of learners that are having better understanding of computers and technology in general than their predecessors. Corner (2013) described that this event fits into the theory of constructivist learning about using what learners already know and leverage the learning of new ideas through using learners' prior knowledge of content and skills. Advocates of technology believe that it has resulted in effective teaching in general (Webb, 2005).

To become an effective Science teacher, teachers must be able to develop appropriate strategies and representations of scientific knowledge in order to achieve fruitful teaching with technologies (Lin, Tsai, Chai & Lee, 2013). As stated by Mishra and Koehler (2006), modern day teachers need to understand the subject matter knowledge, pedagogical knowledge and technological knowledge as well as the relationship among all these required knowledges. As the TPACK model provides teachers the framework of how technology can be integrated in education and how to structure classroom experience in providing the best technology-incorporated educational experience for learners, there is a need for Science teachers to assess their level on the various TPACK constructs. To assess the teachers' TPACK is not only about measuring their understanding of technology, but also consider the knowledge on the subject and how to teach it as technology does not replace pedagogical or content knowledge but enhance another dimension to it. Arguably, the most effective teachers are the ones that understand and use the concepts of TPACK in the classroom. TPACK studies on teachers have not been done in Sarawak yet this research would provides the insights of Sarawakians' primary school Science teachers in their level of TPACK as Sarawak is a state of diversities and the geographic characteristics (locations and educational institutions settings) may influence the teachers' TPACK.

2.3 Factors Influencing Teachers' TPACK

2.3.1 Geographical Settings

Pedersen (2004) indicated that technology has bring changes to teaching methods in supporting the needs of the 21st century teaching and learning environment. This includes the use and application of computers, internet, mobile phones and games; therefore, teachers need new methods of teaching to replace the old methods that suits the digital generations. Teachers are expected to change their teaching approaches and philosophy accordingly to the subject. MOE has indicated that effective teaching with technologies depends on teachers' confidence to use and understand how to integrate technologies into their teaching (Harlow & Cowie, 2010). This is due to different classroom settings that influence the value of technological tools and the effectiveness of such tools to support teaching and learning as well as how such tools are used (Otrel-Cass et al., 2010). Although teachers acknowledge the effectiveness of technology in teaching and learning process, their actual use of technological tools may be affected by how easy they are able to integrate technology effectively in their classrooms. Location of the school may influence teachers to integrate technology in their teaching and learning session. Rural schools with immense road or network access might be lack of technology usage in the classroom compare to urban schools that may have better network connectivity. Different settings shape the teachers' knowledge at global and classroom levels of scope, as well as their political, social, economic and technological conditions (Harris & Hofer, 2017). Harris and Hofer (2017) also added that the specific nature of teachers' TPACK dependent upon the contextual characteristics that may have been conceptualized and operationalized differently in various educational institutions. Literature from past studies has shown that TPACK have been explored mostly by university-based researchers and often related to professional development efforts by the higher education institutions as it was originally intended for teacher educators and popular among higher educational technology educators. However, TPACK has found its way into schools, procedures and policies which derived a question on how is the TPACK constructs understood and used outside the higher education (Harris & Hofer, 2017), thus creating another continuation on this line of study which will focus more on the primary and secondary schools.

2.3.2 Demographic Characteristics

Teachers' perceptions of technology is an important aspect to study their desire towards the usage of the most recent technology in the field of education. Literature have revealed the importance of teacher perceptions as one of the critical factors among teacher readiness to use technology tools in their teaching and learning process. Arguably, technology usage in teaching has been related to the teachers' ability and personal perception in handling any technological tools in the school. Teachers who are confidence in using technological tools would have higher technology integration in their classroom as supported by Onyia and Onyia (2011), which reported that there is a positive correlation between teachers' self-efficacy and the integration of technology. This statement is also supported by Bandura (1997) which stated that teachers' self-efficacy or more known as self-confidence have a huge influence in the use of technology in the classroom. Thus, it is important to take teachers' concerns and dreads into consideration when they use technology in their teaching instruction. Logically, teachers with more teaching experiences in the subject have positive perspectives towards integration of technology in their classroom, as number of practices and their initiatives helps them to easily deliver useful insight about the benefits of using educational technology in teaching and learning process. The more competence and experience teachers have with technology manipulation, the more likely they show positive attitudes towards integration of technology in teaching. Voogt (2010) stated that teachers that frequently integrate technology in their classrooms usually possess high degree of confidence in pedagogical technology skills and focus on learner-centered technique. These teachers have outstanding engagement in professional development activities and collaboration with colleagues as compared to those who don't use technology frequently. To achieve the standard of 21st century teaching and learning, MOE has encouraged educators to practice modern teaching methods with technology integration in subject lesson as one of the requirements to fulfil the MOE's vision. In addition, school management and leadership also can affect teachers' perception on integration of technology in their lessons.

Technology can be an effective tool in providing effective classroom activities and instructions as it is defined as the effective usage in all aspects of educational process including the learning environments. Since the early time, technology implementation in the education system has been playing a crucial role to improve educational qualities. As integrating technology in education can be considered as a complex process, it requires the readiness among teachers to teach the subjects as they might encounters several issues regarding the shortage of facilities (which may be related to the school location and condition), time, teachers' teaching style preferences (modern or conventional teaching method) and knowledge towards the technology itself (Summak, Bağlibel, & Samancioğlu, 2010). The success of technology integration in the classroom depends on the willingness of the subject teachers to adopt and change to positive attitudes towards technology in teaching and learning. Using technology in teaching Science supplies instructional strategies such as provoking cognitive conflicts and provide supports via scaffolding (Lin et al., 2012). As technology have been generally known in sustaining collaborative and problem-based learning, it has become a powerful aid in students' classroom activities and learning instructions. In such situation, Science teachers must be equipped with interrelated knowledge of technology integration in the subject.

Although in the past studies have shown several researches involving innovative approaches of technology implementation in Science classroom, there have been findings that Science teachers are not consistently and extensively using technology in their teaching because there are not fully ready to do so (Webster, 2011). The teachers mostly stated that their own level of comfort with technology and their readiness to implement it in the classroom as low, as well as their expression of their own competencies of educational technologies skills. In addition, the facilities and technology tools provided in schools are varies, especially between rural and urban schools. Although Science teachers indicate their interest to integrate technology in their lesson, they stated their limitations due to inadequate of facilities and teaching practices in doing so (Bauer, 2013).

The past review of literature on the technology usage and intention to use technology from the gender perspective has observed that in few contexts, gender plays a significant role in determining the intention of accepting new technology and there are cases where gender differences cannot be discerned. Despite institutional efforts to reduce gender inequalities, women in many countries in comparison to their male counterparts, encounter a significant disadvantage in areas such as education, politics and workplace discrimination (Goswami & Dutta, 2016). Goswami and Dutta (2016) also pointed out that women faced more challenges in terms of socio-cultural, educational and technological issues than men when managing their business ventures. As past studies of comparing the tendency of technological usage between both genders revealed more favourably towards men compared to women, Goswami and Gutta (2016) has suggested that understanding the reasons behind gender inequalities on the acceptance of new technologies would help in overall development of technologies.

Further examination of the relationship between genders and teachers' TPACK should be examined as the existence of this relationship could provide guidance to policymakers and school administrations in where educational technologies should be incorporated. Based on the literature review in the study by Jang and Tsai (2012) in Taiwan, their findings stated that there was no significant difference of elementary teachers' TPACK based on gender. However, another study by Erdogan and Sahin (2010) on Turkish teachers' TPACK had shown results that the male teachers shown significantly higher TPACK compare to female teachers. There were limited studies on examining the difference on teachers' TPACK by gender and the findings of related study on the relationship of gender and teachers' TPACK varies according to different context, settings and different group of participants.

2.4 Theoretical Background and Factors of TPACK

Educators have recognized that technology skills alone did not serve them well in the pursuit of teaching with technology (Anjeli, 2005). Teachers agreed that technological skills alone are not sufficient to prepare and enable them to effectively teach with technology (Hardy, 2010). Successful technology integration is not dependent on the smart use of educational technologies but rather based on curriculum content and the processes through which students learn such content. To integrate educational technologies effectively into education, teachers need to plan their instruction according to requirements of curriculum, students' learning needs, availability of technology affordances and constraints, and the realities of school and classroom contexts.

To propose a model of how technology can be used most effectively in teaching, Mishra and Koehler (2006) argued that teaching with technology demands knowledge in technology, pedagogy and the content to be taught. The emphasis they articulated was how a teacher can put these constructs together in their teaching. They put together the three constructs (technology, pedagogy and content knowledge) to form the framework known as Technological Pedagogical Content Knowledge. TPACK framework presents an effective frame for thinking about integrating technology through the provision of specific knowledge associated with the integration of technology into the learning environments (Polly & Brantley-Dias, 2009).

There is an urge to understand how knowledge among Science teachers for technology integration develops through their teaching experiences (Hofer & Gradgenett, 2014) in order to provide effective classroom instruction. Shulman (1987) mentioned that a teacher should understand how they should bring together their content and pedagogical knowledge in order to provide effective teaching practice. TPACK is the domain of knowledge where all of a teacher's knowledge intersect and enables them to determine a relationship between the curriculum focus, pedagogical strategies and technologies in the teaching and learning session (Hofer & Grandgenett, 2012). The ability to provide interactive content, feedback, diagnosis of the students' needs, providing effective intervention, assessing learning, and keeping records of student work examples that are provided by technological advancement helps to improve students' learning (Watson & Watson, 2011). Pedagogical content knowledge (PCK) is unique to any educational disciplines. For example, the Science teachers will have or use a form of PCK that differs from the other subject teachers. If technology is to be taken as an important part of teaching and learning, it is crucial for the teachers to not only focusing in developing their PCK but also the understanding of the interactions of technology with PCK. Technology integration in the classroom is primarily about the content and effective instructional practices (Bauer, 2013).

The TPACK model provides a clear concept of how technology can be integrated effectively in teaching and learning process by showing how TPACK affects teachers' choices of technology and pedagogy used in their teaching approach. Teachers that understand the content and pedagogical needs of the subject can identify the constraints and affordances of technology, leading them to make appropriate decisions on the usage of technology effectively in the classroom. Koehler and Mishra (2005) have developed a survey to evaluate the effect of an instructional design course based on their model of TPACK that integrates the seven factors (TK, CK, PK, PCK, TCK, PTK, TPCK). However, the result they obtained reveals only three factors, which indicates that teachers may have difficulties in distinguishing the factors. They also identified that certain constructs of the TPACK contributes more on their overall TPACK such as the technological knowledge (TK) highly contributes to their level of TPACK. However, there is a lack of evidence in discriminating the factors of Science teachers' TPACK than content-general teachers. The uncertainty of which constructs that highly contribute to Science teachers' TPACK may create confusion on the understanding of teachers' competency in teaching with technology from the knowledge perspective, which may lead to a gap in teacher education research and professional development programme.

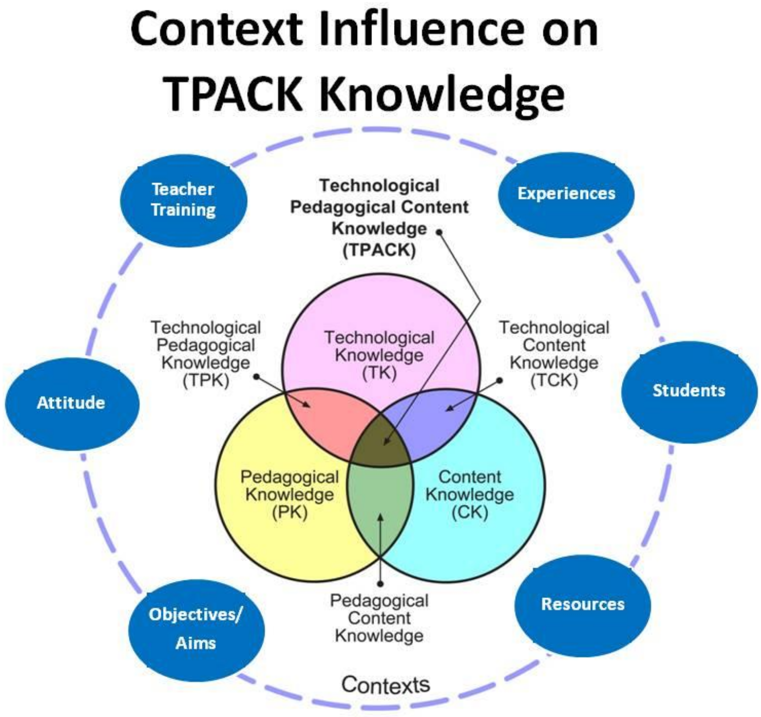

Figure 2.1 Context Influence on TPACK Knowledge (Hofer & Gradgenett, 2014).

2.5 Chapter Summary

In this chapter, the researcher provided an overview of the literature related to this study and the gaps that exist based on the review of past research. In the first section, the researcher reviewed the development and the evolution of technology integration in education specifically in the Malaysian National schools. TPACK framework is an instrument of integrating digital technology into 21st century education and curriculum. The researcher articulated the idea that teachers must understand their level of TPACK and develop technological skills that coincide with the pedagogical integration of technology. The geographical factors such as classroom settings and school locations may also influence the teachers' TPACK. The relationship between teachers' demographic characteristics (gender and teaching experience) and their TPACK must be examined to provide insights to policymakers for future professional development and teacher educational programs. TPACK framework has been promulgated to solve the lack of a unifying concept in the quest to teach with technology (Archambault & Barnett, 2010). The framework is an extension of Shulman's (1986) concept of pedagogical content knowledge, which identifies the distinctive features of knowledge for teaching. The TPACK framework has seven constructs set within the contexts of education. TPACK seeks to explain the knowledge required by Science teachers and educators to effectively use technology in their teaching. It is a framework through which teachers can think about the knowledge required for making instructional decisions that will facilitate effective integration of digital technologies as learning tools in their teaching (Niess, 2011). TPACK constructs that highly contributing to teachers' TPACK must be considered in order to help teachers to identify appropriate professional development and training regarding technology integration in classroom as well as helping students to prepare themselves to meet the requirements needed in the current work force. Thus, as educators it is crucial to create learning environments that able to support the 21st century skills development. The next chapter will be explaining the methodology used in this study.

CHAPTER THREE

METHODOLOGY

3.0 Chapter Overview

This chapter describes the flow of how this research was conducted, the design that was employed for the research and how participants were selected. This chapter also includes the instrument that was used and the data collection procedure as well as how the data was analysed and presented in this chapter. The purpose of this quantitative research was to determine the level of primary school Science teachers' TPACK in Sarawak, along with to find out whether a relationship exists between Science teachers' demographic characteristics (gender and teaching experiences) and school location and which variables have greater influence on their TPACK. The researcher also aimed to assess which of the constructs highly contributed to primary Science teachers' TPACK and thus have a baseline data of the teachers' TPACK in Sarawak.

3.1 Research Design

As suggested by Mishra and Koehler (2006), the research used a quantitative cross-sectional research design. An independent samples *t*-test, ANOVA and the multiple regression were the primary quantitative analysis performed for the inferential test. In addition, in cross-sectional research, data were collected from research participants randomly at a single point in time or during a single brief period. Based on this, the data directly apply to each case at that point in time or during the data collection period and comparisons and test analysis were made across the variables of interest (Johnson, 2001).

The quantitative aspect of the research was attained through the usage of an online survey to collect data to identify primary school Science teachers' levels of TPACK, in addition to determine their perception of the various constructs of the TPACK framework. Survey was used due to its ability to provide an opportunity to reach a large sample size which increases the generalization of the findings.

3.2 Population, Sample and Sampling Procedure

3.2.1 Participants

The study was conducted in national primary schools in Kuching and Bau area in Sarawak and the sample consisted of 84 respondents, all primary school Science teachers. Concerted efforts were made by the researchers to reach as many primary Science teachers as possible within both selected areas.

3.2.2 Sampling Technique

A list of national primary schools was obtained from both Kuching and Bau Education District Office, containing the school's official email address and the contact number of the schools' headmasters. The researcher has sent an invitation to participate in completing a questionnaire through emails, requiring the school's administration officer to forward the invitation to the Science teachers in the school. The questionnaire also has been distributed via Whatsapp and Telegram to the respondents with Science teaching background regardless of gender, race, teaching experience and highest teaching experience.

3.3 Instrument

Instruments are tools used to collect data and for this research, an online survey in the form of questionnaire is accounted as the appropriate data collection tool. The questionnaire was adopted from the work of Schmidt et al., (2009) which consist of seven constructs of the TPACK framework survey for assessing TPACK. The items on each constructs of the online questionnaire were made of close-ended questions with responses options having a five-point Likert scale range from 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree. The questionnaire consists of 8 sections; Section A is main about the demographic information of the respondents which consists of 8 items include gender, race, teaching experience, school area, teaching style preferences, highest academic qualification and the ability of handing ICT in teaching. The other 7 sections emphasize more on the teachers' TPACK. Section B consists of 7 items that looks into teachers' technological knowledge (TK), Section C comes with 9 items to look on the teachers' content knowledge (CK) while Section D consists of 8 items that looks into the teachers' pedagogical knowledge (PK). Section E comes with 8 items to look on the teachers' pedagogical content knowledge (PCK) and Section F comes with 7 items to look on technological content knowledge (TCK). Moreover, Section G looks into teachers' technological pedagogical knowledge (TPK) that comes with 6 items and Section H will look into the teachers' TPACK that consist of 8 items.

3.4 Validity and Reliability

The reliability of the TPACK instrument on internal consistency reliability using Cronbach's α reliability technique has been accomplished multiple times from past research. The scales and subscales for items were measured on the five-point Likert scale based on Cronbach's alpha. Reliability and validity of the subscales range are assumed to be consistent from the range of 0.80 to 0.90. These measurements demonstrated sufficient internal reliability to use the instrument during this study. Yurdakul et al. (2012) conducted validity and reliability studies of a modified TPACK instrument using both an exploratory factor analysis and a confirmatory factor analysis using 995 Turkish pre-service teachers. They determined that the test–retest reliability coefficient of the modified TPACK scale was 0.80 and concluded that the scale was consistent. The Persian version also shown valid and reliable in which the Cronbach's alpha value for the instrument was found to be 0.80 indicating that the questionnaire had good internal consistency (Kamal & Hosseini, 2013) and sufficiently reliable for assessing the primary Science teachers' TPACK for the study (Meng, Sama, Yew, & Lian, 2014).

3.5 Pilot Study

The questionnaire was transformed into an online survey through Google Form and the link was shared via Whatsapp and other social media. It was conducted on a small group of Science teachers (30 teachers) from selected primary schools in Kota Samarahan The selected primary Science teachers were not included by the intended survey population as this the pilot study was to examine any resulting changes in the validity or reliability of the instrument used. A list of primary schools in Kota Samarahan was obtained from the Education District Office. The online questionnaire was forwarded via the school's official email and the headmaster, enabling the administrations officers to distribute the questionnaire to Science teacher to try it out. Thirty Science teachers from primary schools in Kota Samarahan are targeted to complete the trial online questionnaire**.** The responses from those teachers were collected and used to determine the reliability of the instrument before it will be sent out for the main study.

3.6 Ethics of the Study

The researcher had made sure every research that involve human participants was conducted with appropriate regard for ethical principles, confidentiality and cultural values. The researcher has ensured that participants of the research were informed of the appropriate and detailed information of the study. Prior to agreeing to participate, the participants must be treated with respect, their safety assured, and their details were kept confidential.

A letter of information about the project including a brief description with the research questions was developed, indicating the expectations of response from the teachers and the time commitment to complete the questionnaire, information about the use of data and the guarantee of anonymity and confidentiality. The first page of the online survey was a consent page which contained the information about the research. Contact details of the researcher was included, in any case the participants may have questions regarding of this study, as well as the estimated time it will take teachers to respond to the items. Respondents needed to agree to be part of this study before they could proceed and have access to the following items in the questionnaire. Consent from the Education Ministry or Education District Authority must be obtained before carrying out the research. Researcher also must ask for permission from the teachers to take part in this study.

3.7 Data Collection Procedure

The survey was formed using an online Google Form. A complete listing of primary schools in Bau and Kuching was obtained from the Education District Office (EDO) with the EDO approval. A preparatory email was sent to the schools and another via text message (Whatsapp) to the schools' headmasters to inform of the proposed research study to ensure that the schools understand the context of the study and that participation was encouraged but was strictly voluntary. The e-mail and Whatsapp text invitation to participate contained a unique participant link for each participant's response. The informed consent form is included as the first page the participants viewed. The survey was constructed so that each participating respondent acknowledged the informed consent banner prior to initiating the survey. This was done to assure teachers of the confidentiality of their responses before they will click on the link to the survey. The survey was distributed, and survey data were collected after 14 days. Reminders to participate was sent every 3 days to those who had not responded. All the complete questionnaires were gathered for SPSS data analysis to get the output and findings for this study.

3.8 Data Analysis Procedures

The responses from the participants were exported to SPSS version 22 for both descriptive and inferential test analysis. Only completed responses of the questionnaires were used for the analysis. The data cleaning process was conducted to delete the incomplete questionnaires. The first phase of data analysis was to label and rename data into numeric form and assigned the type for all variables. Descriptive analysis were used to analyse the frequency and percentage of the overall population in the demographic information, as well as to identify the mean, standard deviation, frequency and percentage of the primary Science TPACK in national primary schools in Kuching and Bau. Meanwhile for the inferential analysis, an independent sample *t*-test analysis, Pearson correlation and multiple regression analysis were used to analyse the research hypotheses developed in this study. The inferential test used for the hypotheses testing was is summarized as shown in table 3.1 and table 3.2.

Table 3.1
Map of Inferential Statistical test for Hypotheses Testing.

Research Question	Independent Variable	Dependent Variable	Analysis
2	School location	TPACK	Independent samples *t*-test
3	Demographic factors: Gender Teaching experience	TPACK	Independant sample *t*-test One way ANOVA

Table 3.2
Map of Multiple Regression test.

Research Question	Predictor	Criterion	Analysis
4	CK, PK, TK, PCK, TCK, PTK	TPACK	Multiple regression

3.10 Summary

In this chapter, the researcher addressed the research design, the instrument, data collection, and procedures of data analysis for this study. The selection of appropriate methodological design for this research was informed by the objectives of the research. The aims of the research were to collect data in order to measure primary school Science teachers' TPACK. The quantitative aspect of the research was attained through an online survey which were sent to national primary schools in Kuching and Bau via mobile networking. The data generated from the survey were analysed to find the mean responses for each of the constructs in the questionnaire. The Cronbach's Alpha reliability testing was used to test the internal consistency of an instruments and its items, which was also considered as a measurement of scale reliability. This research used the 5-points Likert scale which accepted the alpha value within the range of 0.70 - 0.80. In Chapter 4, the researcher will report the findings of the test analysis of this research project.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter revealed the results obtained from this study to answer the research questions and testing the hypothesis created by the researchers. It also describes the demographic profile of the respondents involved in this study. The results are expressed in two parts which are descriptive and inferential analysis.

4.1 Report of the Pilot Study

The online survey was piloted on a small group primary schools Science teacher in Kota Samarahan, Sarawak. Thirty of primary Science teachers were selected randomly and the online survey was sent via Whatsapp sharing for them to respond to the questionnaire. The responses from the pilot participants were collated The responses from these teachers were collated using the SPSS Version 22 for statistical analysis and used to determine the reliability of the instrument before it was sent out for the main study.

The survey reliability analysis of the pilot study revealed that the adopted instrument used exhibited strong reliability. The Cronbach's α score for the instrument was α=0.961 and the Cronbach's α score of the three major components were: technology knowledge (α=0.82); CK (α=0.90) and PK (α=0.84). According to Field (2009), an overall Cronbach's α score of 0.97 is excellent and a Cronbach's α score 0.60 or higher is acceptable for social sciences. Since all the values were above 0.5, all items were deemed to be very reliable to fairly reliable. Therefore the questionnaire was proven to be reliable to collect data for this research. Table 4.1 summarizes on the result of reliability test.

Table 4.1
Specifications of Predictor Variables

Variable	Type	No. of items	Reliability
Technological Knowledge (TK)	Predictor		0.884
Pedagogical Knowledge (PK)	Predictor		0.833
Content Knowledge (CK)	Predictor		0.901
Pedagogical Content Knowledge (PCK)	Predictor		0.545
Technological Content Knowledge (TCK)	Predictor		0.649
Technological Pedagogical Knowledge (TPK)	Predictor		0.826
Technological Pedagogical Content Knowledge (TPACK)	Predictor		0.665

4.2 Demographic Profile of Respondents

Table 4.2 show the profile of respondents that involved in this study. From the overall population (n=84), the highest frequency of respondents based on gender are female with 53 respondents who represent 63.1% of the population compared to only 31 male respondents with a percentage of 36.9%. As for teaching experience, most of the respondents have more than 10 years of teaching experience with 34 (40.5%) followed by 6-10 years of experience with 24 (28.6%), then 1-5 years of experience with 20 (23.8%) and 6 (7.1%) respondents with less than 1 year of experience. As for school area, there are slightly more respondents teaching in school located in urban area with 43 (51.2%) compared to respondents who are teaching in rural school with 41 (48.8%). As for preference of teaching style, majority of the respondents preferred modern/contemporary teaching style with 63 (75%) as compared to 21 (25.0%) respondents who choose conventional/traditional teaching style.

As for highest academic level, most of the respondents are degree holder with 56 (66.7%), followed by KPLI/DPLI (Post-Degree Teacher’s Training) with 15 (17.9%), then respondents with master's degree with 10 (11.9%), next diploma qualification with 3 (3.6%) and no respondent with doctorate degree. Finally, as for the ability of handling ICT in teaching, majority of the respondents believe that they have medium ability with 54 (64.3%), followed by high ability with 25 (29.8%) and low ability in handling ICT with only 5 (6.0%).

Table 4.2

Profile of Respondents

Factors	Frequency	Percentage (%)
Gender		
Male	31	36.9
Female	53	63.1
Teaching Experience		
<1 year	6	7.1
1-5 years	20	23.8
6-10 years	24	28.6
>10 years	34	40.5
School location		
Urban	43	51.2
Rural	41	48.8
Preference of teaching style		
Modern/Contemporary	63	75.0
Conventional/Traditional	21	25.0
Highest academic level		
Diploma	3	3.6
Degree	56	66.7
KPLI/DPLI	15	17.9
Masters' Degree	10	11.9
The ability of handling ICT in teaching		
Low	5	6.0
Medium	54	64.3
High	25	29.8

4.2.1 Technological Pedagogical Content Knowledge of Primary Science Teachers

Objective 1: To measure the primary Science teachers' TPACK score.

The first research question sought to identify Bau and Kuching primary school Science teachers' TPACK score. When asked to rate their own understanding in teaching

Science based on the various constructs of TPACK on a five-point (strongly disagree-strongly agree) Likert scale, the teachers demonstrated a much more appealing level of understanding on the Content Knowledge (n=4.08) and Pedagogical Knowledge (n=3.98) of the subject as can be seen in Table 4.3. However, the lowest mean score among the various TPACK construct is the Technological Knowledge (n=3.58). The overall mean score for TPACK is 3.65. Teachers' high mean scores in the CK and PK indicated that they possess more knowledge in the content and pedagogical constructs in teaching Science subject.

Table 4.3

Primary Science teachers' mean scores on the construct of TPACK.

Constructs	N	Mean	Std. Deviation
Technological Knowledge	84	3.58	.76
Content Knowledge	84	4.08	.60
Pedagogical Knowledge	84	3.98	.49
PedagogicalxContent Knowledge	84	3.88	.48
Technological Content Knowledge	84	3.73	.65
Technological Pedagogical Knowledge	84	3.71	.69
Technological Pedagogical Content Knowledge	84	3.65	.69

Mean scores of teachers' responses on each item were calculated to ascertain how they responded to the items under each construct. This was done to identify if there were specific items which needed attention. Table 4.4 presents teachers' response patterns for the items of the technological knowledge construct. TK construct has shown the lowest mean score among all other constructs under TPACK (n=3.58). The responses revealed a higher mean score on the item No. 2 and No. 7 (n-3.71) which can conclude that teachers were confident and comfortable when it came to install a new computer program they would like to use on their computer and keeping up with updated and new technologies. Aside this item, lowest mean score (n=3.35) was for the item "I have had sufficient opportunities to work with a range of technologies". If teachers have not had sufficient opportunities to work with technology, then their technological skills will definitely be limited and thus it was not surprising that their mean score for TK was generally low as compared to the other constructs of the TPACK framework. It is also concluded that there is no standard value for TPACK to derive whether the level is high or low since the teachers' TPACK level varies based on their background factors.

Table 4.4

Mean scores for Technological Knowledge items.

TK Items	N	Mean	Std. Deviation
I know how to solve my own technical problems.	84	3.69	.72
I keep up with new important technologies.	84	3.71	.75
I know about a lot of different technologies.	84	3.47	.73
I have the technical skills to use technologies.	84	3.64	.67
I have had sufficient opportunities to work with a range of technologies.	84	3.35	.70
I can learn to use software easily on my own.	84	3.52	.91
I can install the new program that I would like to use.	84	3.71	.85
(mean= 3.58, SD= 0.76)			

4.3 Hypotheses Testing

Objective 2: To determine if primary Science teachers' TPACK varies according to school location.

The types of inferential statistical test suitable to analyse objective 2 is the independent samples *t*-test. The independent samples *t*-test was used to compare the means of two independent groups (school location: urban and rural) in order to determine whether there is statistical evidence that the associated population means are significantly different.

H_0: There is no significant difference in primary school Science teachers' TPACK based on school location (urban and rural).

Several checking processes were carried out in order to meet the assumptions of the independent samples *t*-test. Sampling was made randomly, the dependent variable (Science teachers' TPACK) was in scale measurement and the independent variable (school location) was categorical. Skewness and Kurtosis of urban schools are -.779 and .868 respectively while rural schools are -.096 and .734 respectively with p-value was larger than .005 (p=.378), the data was assumed to be normally distributed.

Table 4.5

Group Statistics.

	School location	N	Mean	SD
TPACK	Urban	43	29.16	4.81
	Rural	41	29.34	4.22

Table 4.6

Independent t-test between the primary Science teachers' TPACK based on school location.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TPACK	Equal variances assumed	.785	.378	-.237	82	.857	-.17867	.99009	-2.14828	1.79093
	Equal variances not assumed			-.242	81.47	.857	-.17867	.98704	-2.14239	1.78504

The result in table 4.6 indicates that there is no significant difference between the primary Science teachers' TPACK based on school location (t=-0.180, df=82, p>0.05).

Therefore, the null hypothesis is failed to be rejected. The Science teachers' TPACK in urban schools (M=29.16) and rural schools (M=29.34) are more less the same.

Objective 3: To determine how demographic factor such as gender and teaching experience correlate with the primary school Science teachers' TPACK.

$H_0(1)$: There is no significant difference in primary school Science teachers' TPACK based on gender.

To analyse objective 3, independent sample *t*-test was used to determine if there is a significant different between gender (male and female) and their TPACK score. The result of the independent *t*-test is shown in Table 4.8.

Table 4.7

Group Statistics

	Gender	N	Mean	SD
TPACK	Male	32	29.09	4.30
	Female	53	29.33	4.33

Table 4.8

Independent t-test between the primary Science teachers' TPACK based on gender.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TPACK	Equal variances assumed	.028	.869	-.237	82	.813	-.24285	1.02546	-2.28282	1.79712
	Equal variances not assumed			-.242	67.16	.810	-.24285	1.00357	-2.24590	1.76020

The findings indicated that there is no significant difference between the primary Science teachers' TPACK based on gender (t=-0.028, df=82, p>0.05). Therefore, the null hypothesis is failed to be rejected. The TPACK score between male (M=29.09) and female (M=29.33) Science teachers are almost similar.

$H_0(2)$: There is no significant difference in primary school Science teachers' TPACK based on teaching experience.

To analyse the relationship between demographic factor (teaching experience) and primary Science teachers' TPACK, one-way ANOVA test was used. Independent variable is the years of teaching (ordinal measurement) and the dependent variable is the TPACK score (scale measurement). Table 4.9 shows the result of the test.

Table 4.9

One-way ANOVA shows the relationship between primary Science teachers' teaching experience and their TPACK score.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	430.533	3	143.511	9.132	.000
Within Groups	1257.217	80	15.715		
Total	1687.750	83			

The result in Table 4.9 shows the value $F(df=3,80) = 9.132$, $p<0.05$ which concludes that the null hypothesis is rejected. The ANOVA test shows that there is a significant difference between the teaching experience and the Science teachers' TPACK score. The Tukey HSD post hoc multiple comparison test results show that the significant different occurs between group of teachers with more than 10 years teaching experience compare to the other groups. The homogenous sub-sets table shows that the mean score of group >10 years teaching experience is lower than the mean of the other groups. Therefore, it is concluded that teachers with teaching experience more than 10 years has less understanding in their technological pedagogical content knowledge.

Table 4.10

Multiple Comparisons

(I) Exp	(J) Exp	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
< 1 year	1 - 5 years	-4.30000	1.84525	.100	-9.1417	.5417
	6 - 10 years	-3.54167	1.80942	.213	-8.2893	1.2060
	> 10 years	.70588	1.75540	.978	-3.9000	5.3118
1 - 5 years	< 1 year	4.30000	1.84525	.100	-.5417	9.1417
	6 - 10 years	.75833	1.20023	.921	-2.3909	3.9076
	> 10 years	5.00588*	1.11713	.000	2.0747	7.9371
6 - 10 years	< 1 year	3.54167	1.80942	.213	-1.2060	8.2893
	1 - 5 years	-.75833	1.20023	.921	-3.9076	2.3909
	> 10 years	4.24755*	1.05689	.001	1.4744	7.0207
> 10 years	< 1 year	-.70588	1.75540	.978	-5.3118	3.9000
	1 - 5 years	-5.00588*	1.11713	.000	-7.9371	-2.0747
	6 - 10 years	-4.24755*	1.05689	.001	-7.0207	-1.4744

*. The mean difference is significant at the 0.05 level.

Objective 4: To determine the predictor of Science teachers' TPACK.

H_0: There is at least one of the constructs contributing significantly to primary Science teachers' TPACK.

Since TPACK is the intersection of the contributing constructs, in order to identify which independent variable was the largest predictor of TPACK, when all the other variables have been considered, a standard multiple regression was performed. TPACK was the dependent variable while TK, CK, PK, PCK, TCK and TPK were the independent variables. This could help teacher educators and professional development organizers to know which construct to focus on in their programmes. The various assumptions underlying multiple regression were examined.

Table 4.11

Model summary for the multiple regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.885[a]	.784	.781	2.10999

a. Predictors: (Constant), TPK

b. Dependent Variable: TPACK

Table 4.12

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1322.681	1	1322.681	297.094	.000[b]
	Residual	365.069	82	4.452		
	Total	1687.750	83			

a. Dependent Variable: TPACK

b. Predictors: (Constant), TPK

Table 4.13

Regression analysis for construcr predicting TPACK

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.171	1.530		2.072	.041
	TPKmean	1.169	.068	.885	17.236	.000

a. Dependent Variable: TPACK

Table 4.14

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	CKmean	.029[b]	.560	.577	.062	.963
	PKmean	.097[b]	1.848	.068	.201	.925
	PCKmean	.006[b]	.100	.921	.011	.812
	TCKmean	.142[b]	1.601	.113	.175	.329
	TKmean	.066[b]	.906	.367	.100	.494

a. Dependent Variable: TPACKmean

b. Predictors in the Model: (Constant), TPKmean

It can be seen from Table 4.11, that TPK made the largest unique contribution to the development of TPACK. The beta value for this construct was 0.885. Although the overall multiple regression was significant, it was seen that only TPK ($p < .001$) made a statistically significant unique contribution to teachers' TPACK.

4.5 Summary

The findings of this study showed important responses from primary Science teachers which revealed that they used technology to facilitate their lesson preparation more than any other activity. They used technological tools to search for information, content material and videos to facilitate their students' understanding of science concepts. The TPACK assessment were expressed in descriptive and inferential statistical analysis. The analysis of the survey data has brought to fore how Sarawak Science teachers perceive their understanding of the technology integration by using the TPACK framework. The responses of the teachers showed that they fall between agreed with most of the items under the various constructs which when translated indicated that they had high opinion of themselves when it came to the constructs of the TPACK framework. The only construct that did not receive high rating was Technological Knowledge. The teachers felt that their TK was limited as compared to the other constructs of the TPACK framework. This study also analysed the association of different factors used in the questionnaire to some of the demographic variables. The regression analyses revealed that the primary school Science teachers' TPACK in Sarawak was predicted by their TPK and TCK. The next chapter will be focused on the discussion of the issues in this study.

CHAPTER 5

DISCUSSION

5.0 Chapter Overview

This is the concluding chapter of the report. It presents the summary of the research including the design used, limitations and findings as well as the conclusions drawn from the results and how they may affect educational practice and ends with recommendations and areas for future research This chapter also takes a critical look at the results of the research and compares them to findings in the literature.

5.1 Discussion

Based on the respondent profiles, it shows more primary Science teachers agree with the technology integration in teaching and learning which contributes to the effectiveness of teaching compare to conventional teaching style. This could be due to the ability of technological tools to create and promote a more active learning environment that appears to be more interesting and engaging for both teachers and students. It was found that the primary school Science teachers felt quite confident with their TPACK. The results are in line with the research findings by Gulbahar and Guven (2008) that stated the integration of technology in teaching and learning facilitates teachers and students to improve and expand the quality of education by extending curricular support in certain content area which may be considered as having a higher difficulty level to comprehend. Aligned with the statement by Onyia and Onyia (2011), teachers are having more confidents when integrating technology in their teaching since it promotes a much more embellish instructions and easier to deliver useful insights. When the data were analysed, it was determined that teachers are more knowledgeable in the pedagogical and content fields than in technology, which means that their level of technological knowledge does not suffice to integrate technology into their teaching tasks (Roig-Vila et al., 2015). Primary Science teachers who participated in this survey rated "Technology Knowledge" (M=3.58) lower than the other TPACK subscales. According to Mishra & Koehler (2006) Technological Knowledge is associated with the ability to use technological tools but also the knowledge behind this technology which enables teachers to effectively apply technological knowledge to improve student learning and to be ready to any forthcoming changes. In align with this, teachers seem to have lower value of Technological Pedagogical Knowledge (TPK, 4.71) compared to other constructs of TPACK. This shows that primary Science teachers may find difficulties on the understanding that teaching and learning are reformed when using technological tools in designing pedagogical strategies considering all available technological tools are designed to fulfil educational aims of the subject (Mishra & Koehler, 2006).

Based on the result of independent sample t-test, the result shows there was no significant difference in the use of technology in teaching and learning in urban and rural schools. The primary Science teachers' TPACK did not differ regarding to school location. According to Kamal and Hoseini (2014), most teachers of younger generations (millennials) are already equipped with the basic knowledge of using technological tools in consequence to no significant difference between urban and rural school teachers. Some teachers who have high technological skills and knowledge may have placed in-service in the rural schools while veteran teachers (where most probably has lack of skills in handling technological tools) may teach in the urban schools. In addition, the result obtained might be due to the government initiative in providing laptops and other technology tools to schools. However, teachers' professional development specifically on technology integration in classroom are not adequately provided, where most teachers learn through self-initiatives. Teachers are expected to be well equipped with the needed knowledge before they can successfully transfer knowledge to students. However, not all teachers obtain the required level of knowledge of using technology. A report by Rosnaini and Mohd. Arif (2010) stated that only minority group of teachers were knowledgeable in basic ICT while most of them only possess average or very minimal knowledge of ICT. This resulted to some teacher who depends on their self-thought and initiative on using technology in their teaching, as well as resulting to various perceptions on how important technology should be integrate in classroom orchestrations.

Another result also shows no significant difference between Science teachers' TPACK according to their gender. Both male and female teachers has the same opportunities in developing their technological skills in school. As stated by Thomas and Stratton (2006), the confidence of practicing technology integration in a classroom depends on the teachers' perceptions and experiences, knowledge level, attitudes, educational applications, the expected outcomes as well as their teaching and learning technique, thus were not influenced by demographic factors such as age and gender. Such result revealed that the primary school Science teachers has almost the same level of perceptions on the technology integration in the classroom. The result from hypotheses testing 2 also shows that there was a significant difference between teaching experience and the teachers' TPACK where primary Science teachers with more than 10 years' experience in teaching Science have lower TPACK score compare to other groups. This probably due to the fact that Science teachers that have teach more than 10 years are senior teachers that were used to convey teaching in conventional style. Although they have good understanding in the content and pedagogical knowledge of the subject, those teachers might not be ready to adapt with rapid changes in technology development. According to Yousef Mai and Hamzah (2016), researchers found that veteran teachers personally held values to do with the desirability of technology and wider concerns regarding its impact on society. They also may fear of getting things wrong when using new software and digital tools. Those reasons are considered as significant factors that were holding back technology integration in classroom among older teachers. Some older teachers are put off using online tools because they view technology ss being arduous and very time consuming. They feel that the trend toward online services such as forums on websites places a greater burden in becoming experts in the technological field in education (Voogt, 2009). Jones et al. (2003) also stated that older teachers have security concerns many of them are lack in confidence in their own knowledge of how to use technological tools properly.

The regression analysis has revealed that of all the constructs, Technological Pedagogical Knowledge (TPK) is the major predictor of TPACK compare to the other constructs that does not make any major statistically significant contribution to the primary Science teachers' TPACK. The result had indicated that the TPK would be the appropriate competency that a teacher should have. Accordingly, it would be useful for educators and teachers' professional development organizers to know which construct to focus on in the development programme, therefore they should organize more trainings for teachers which focusing in developing more of their technological pedagogical knowledge.

5.2 Conclusion

The discussion has revealed that teachers in Kuching and Bau in general has accept that they have more time to cater to students' need when using technology in their lessons. The usage of technology is able to provide encouraging environment for the students to communicate more with their classmates to complete their tasks or assignments. This kind of environment will increase students' confidence to participate actively during the learning process or discussion which further promote effective learning. Most teachers agreed that technology can expand their students' knowledge paradigm. With the emerging development of technology nowadays, students can access information quickly and easily. The variety of educational materials available online such as interactive videos and animations can improve students' ability in reading and writing. In conjunction with this benefit, technological tools enable students to express their ideas and thoughts better. Thus, it can be concluded that the use of technology not only able to control students' behaviour but promotes active and engaging lesson for their best learning experience. This research also gives findings on teacher that they have a positive perception on the technological skills. However, most teachers shared the same perception on the functionality and usability of technology tools in enactment of their pedagogical plans. This research therefore provides new empirical evidence to support the claim that TPACK assessment helps teachers to integrate technology in classroom that will contributes to a much more effective and active teaching and learning.

5.3 Implications

The integration of technology in teaching and learning need serious consideration in order to improve the quality of our education system. This will help in achieving the world ranking on the national education and produce competitive world class future work force. To achieve our national education vision and mission, the use of technology in the classroom need to be enhanced. With the help of our government, teachers' confidence and perceptions about the integration of technology in classroom need to be improved, as the teachers' role is the key role in making any of the new education system policy to be implemented efficiently and successfully. The changes that is taking place is driven by advanced technology and communication devices and should be available to diverse of students no matter where they are, either home or at school. Moreover, the needs for teachers to become technology literate and have good skills and knowledge in using technology to improve their enactment of pedagogical plans is desired to promote effective learning as well as to meet the demand of the 21st century education.

5.4 Recommendations

It is common for issues and challenges of technology integration to be discussed but in-depth study of technology integration in core subjects in schools is least discussed. It will provide benefits if further studies can be made based on what barriers or breakdowns teachers are facing in using technology in their teaching in schools. Besides, rather than just focusing on two area, which is Kuching and Bau, it is best if this study can be conducted throughout Sarawak because some schools might have more fundings that makes technology implementation much faster and easier. Other than that, it is also recommended to conduct comparison studies about technology integration in teaching and learning between public and private schools. This is because most private schools are equipped with better facilities in classroom and laboratories. Private schools also permit students to bring gadgets and teaching and learning process takes place within the use of technology.

There should be an effort to dissuade teachers from making their teaching assessment driven since teachers indicated that their use of technology was influenced by how much they learn from peers or from professional development training. Rather, they should be encouraged to focus on what and how students might learn what they need to know and do and therefore how technology can assist learning. There are many teachers in the school system who trained at a time when the use of technology was less important. Therefore, teachers should be offered professional learning on how to use technology to foster inquiry that would cover a large amount of content knowledge at the same time so that students' own expertise is leveraged. There should be conscious leadership training for teachers on how to use and share their use and applications of technology to teach since teachersxrelied on and valued their colleagues' knowledge when it came to teach with technology. Should the research will be carried out in the future, it is recommended that the researcher should place more focus on a wider range of demographic characteristics, such as age. The outcome from the investigation of the relationship between TPACK level according to age would benefits any educational training programmes when putting the consideration of comparing the significant difference between a much more older teacher and a fresh-graduate teachers.

5.5 Chapter Summary

It can be concluded based on the results of this study that most teachers' perception on technology integration in teaching and learning in Kuching and Bau schools are positive towards effective classroom orchestration in creating a much more engaging and active learning environment. The initial stage of technology implementation must be effective to make sure that teachers and students are able to make the best use of it. Therefore, preparations of a technology-based teaching and learning begin with proper implementation and supports by the school management and community. If the implementation process of technology integration in schools take place appropriately from the initial stage and maintenance are adequately provided, technology integration in schools will result in a huge success and become beneficial for both teachers and students. The use of technology especially in teaching and learning is more about practicality as compared to theories and that is why teachers must be given time to learn and explore it before they are completely comfortable with its usage and able to make use of it for teaching and learning.

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APPENDIX

Appendix A

Research Questionnaire

Assessing Primary School Science Teachers' Technological Pedagogical Content Knowledge (TPACK) in Sarawak

Dear Sir/ Madam,

Please spend 20 minutes to complete this questionnaire form.

The purpose of this questionnaire is to study the Science techers' TPACK. There will be eight sections which are Section A (demographic profile), Section B (Technological Knowledge), Section C (Content Knowledge), Section D (Pedagogical Knowledge), Section E (Pedagogical Content Knowledge), Section F (Technological Content Knowledge), Section G (Technological Pedagogical Knowledge) and Section H (Technological Pedagogical Content Knowledge) in this questionnaire. Please answer all questions by following the instruction given. I would be most grateful if you could take a little time to complete this short questionnaire. Information or data obtained from the respondents are assured to be strictly kept CONFIDENTIAL and only for academic purposes. Therefore, please answer the questionnaire confidently and honestly. Your cooperation is highly appreciated. Thank you.

For any inquiry, please communicate with me:

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University Malaysia Sarawak (2019)

Please tick (√) the most appropriate answers.

A. Demographic Questions

1. Gender : ☐ Male ☐ Female

2. Race :

☐ Malay

☐ Chinese

☐ Sarawakian Natives

☐ Sabahan Natives

☐ Others

3. Teaching experience :

☐ <1 year

☐ 1-5 years

☐ 6-10 years

☐ >10 years

4. School location :

☐ Urban

☐ Rural

5. Preference of teaching style :

☐ Conventional/Traditional

☐ Modern/Contemporary (Use of ICT)

6. Highest academic level :

☐ Diploma

☐ Degree

☐ KPLI/DPLI

☐ Master's Degree

☐ Others, please specify ______________________

The ability of handling ICT in teaching :

- [ ] High
- [ ] Medium
- [ ] Low

B. Teachers' Technological Knowledge (TK)

This section is aimed at obtaining your understanding of your TECHNOLOGICAL KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I know how to solve my own technical problems.	1	2	3	4	5
2.	I keep up with new important technologies.	1	2	3	4	5
3.	I know about a lot of different technologies.	1	2	3	4	5
4.	I have the technical skills to use technologies.	1	2	3	4	5
5.	I have had sufficient opportunities to work with a range of technologies.	1	2	3	4	5
6.	I can learn to use software easily on my own.	1	2	3	4	5
7.	I can install the new program that I would like to use.	1	2	3	4	5

C. Teachers' Content Knowledge (CK)

This section is aimed at obtaining information on the teachers' content knowledge. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I have sufficient knowledge about the subject I teach.	1	2	3	4	5
2.	I have various ways and strategies of developing my understanding of the subject that I teach.	1	2	3	4	5
3.	I have a deep and wide understanding of the subject that I teach.	1	2	3	4	5
4.	I can comfortably plan the scope and sequence of concepts that need to be taught within my class.	1	2	3	4	5
5.	I know about various examples of how my subject matter applies in the real world.	1	2	3	4	5
6.	I can use a scientific way of thinking.	1	2	3	4	5
7.	I have good understanding of the Nature of Science.	1	2	3	4	5
8.	I follow up-to-date resources and developments in my subject area.	1	2	3	4	5

D . Teachers' Pedagogical Knowledge (PK)

This section is aimed at obtaining information on your understanding on PEDAGOGICAL KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I know how to assess students performance in the classroom.	1	2	3	4	5
2.	I can adapt my teaching based upon what students currently understand or not understand.	1	2	3	4	5
3.	I can adapt my teaching style to cater for diverse learners.	1	2	3	4	5
4.	I can use a wide range of teaching approaches in a classroom setting.	1	2	3	4	5
5.	I can use different assessment tools and techniques.	1	2	3	4	5
6.	I know how to organize and maintain classroom management.	1	2	3	4	5
7.	I can determine the strategy best suited for the lesson I teach.	1	2	3	4	5
8.	I am able to prepare lesson plans for the various topics that I teach.	1	2	3	4	5

E. Teachers' Pedagogical Content Knowledge (PCK)

In this section, you will be asked to report on your understanding of PEDAGOGICAL CONTENT KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I can select effective teaching approaches to guide student thinking and learning in my subject matter.	1	2	3	4	5
2.	I can produce lesson plans with a good understanding of the topic in my subject matter.	1	2	3	4	5
3.	I can anticipate likely students misconceptions within a particular topic.	1	2	3	4	5
4.	I can assist students in identifying connections between various concepts in my subject matter.	1	2	3	4	5
5.	I can distinguish between correct and incorrect problem solving attempts by student within my class.	1	2	3	4	5
6.	I am familiars with common student understandings and misconceptions in my subject matter.	1	2	3	4	5
7.	I am able to meet my objectives described in my lesson plans.	1	2	3	4	5
8.	I explicitly target aspects of the Nature of Science when teaching,	1	2	3	4	5

F. Teachers' Technological Content Knowledge (TCK)

In this section, you will be asked to report on your understanding of TECHNOLOGICAL CONTENT KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I know about technologies that I can use for teching specific concepts in my subject matter.	1	2	3	4	5
2.	I know how my subject matter can be represented by the application of technology.	1	2	3	4	5
3.	I know about technologies that I can use for enhancing the understanding of specific concepts in my subject matter.	1	2	3	4	5
4.	I can use technological representations (multimedia, visual demonstrations, etc) to demonstrate specific concepts in my subject matter.	1	2	3	4	5
5.	I can use various types of technologies to deliver the content of my subject matter.	1	2	3	4	5
6.	I can use technology to make students observe phenomenon that would otherwise be difficult to observe in my subject matter.	1	2	3	4	5
7.	I can use technology to create and manipulate models of scientific phenomenon (animations, modelling, etc.).	1	2	3	4	5

G. Teachers' Technological Pedagogical Knowledge (TPK)

In this section, you will be asked to report on your understanding of TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I can choose technologies that enhance the teaching approaches for a lesson.	1	2	3	4	5
2.	I can choose technologies that enhance students learning of a concept,	1	2	3	4	5
3.	I can choose technologies that are appropriate for my teaching.	1	2	3	4	5
4.	I can apply technologies to different teaching activities.	1	2	3	4	5
5.	I can effectively manange a technology-rich classroom.	1	2	3	4	5
6.	I can use technologies that can assess students learning.	1	2	3	4	5

H. Teachers' Technological Pedagogical Content Knowledge (TPACK)

In this section, you will be asked to report on your understanding of TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE. Please kindly thick in a box that best fits your abilities:

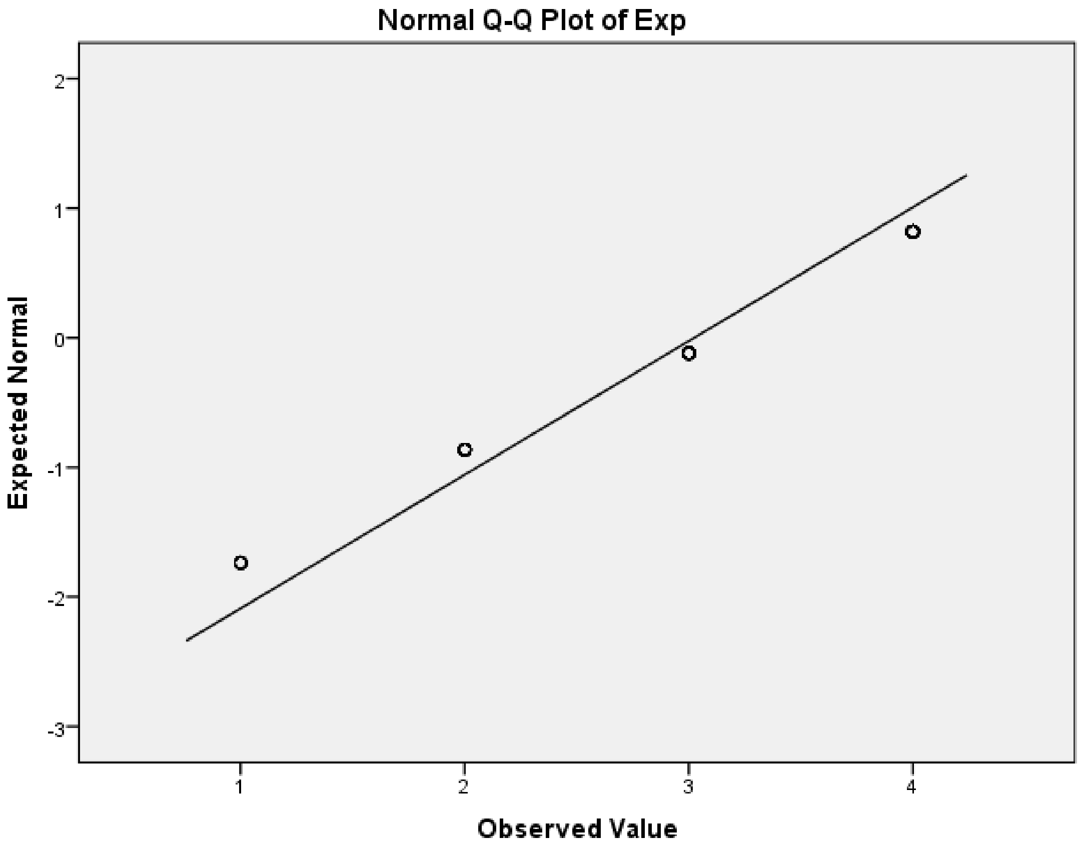
1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

No.	Items	1	2	3	4	5
1.	I can teach lesson that appropriately combine my subject matter, technologies and teaching approaches.	1	2	3	4	5
2.	I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.	1	2	3	4	5
3.	I can use technologies that combine content, technologies and teaching approaches in my classroom.	1	2	3	4	5
4.	I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches in my school.	1	2	3	4	5
5.	I can choose the technologies that enhance the understanding of the content for a lesson.	1	2	3	4	5
6.	I am able to find and use online materials that effectively demonstrate a specific scientific principle.	1	2	3	4	5
7.	I can use technology to facilitate scientific inquiry in the classroom.	1	2	3	4	5
8.	I am able to use technology to create effective representations of content that departs from textbook approaches.	1	2	3	4	5

Thank you.

Source: Schmidt et al. (2009)

Appendix B


Normal Q-Q Plot of Exp
Expected Normal
Observed Value
2
1
0
-1
-2
-3
1
2
3
4