Teachers' TPACK and Technology Integration in Teaching and Learning: A Case Study in The Maldives

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Digital technology, Information and communication technology, ICT, teacher professional development, technology integration, pedagogy, classroom practices, student cognitive engagement, technological pedagogical and content knowledge, TPACK.

Abstract

A significant policy agenda in the Maldives has recently been directed towards improving education for all by levering digital technology. In line with these policy directives, the Ministry of Education has been providing schools with both technology infrastructure and training programs. However, research has shown that the success of technology integration initiatives hinges on the knowledge and skills of teachers to effectively integrate technology in classroom teaching. Consequently, gaining an understanding of teachers' technology knowledge and its integration can provide valuable insights on strategies that can be adopted to enhance teaching, especially in developing country contexts such as the Maldives, where research is scant.

This explanatory mixed-method study investigated Maldivian secondary education teachers' knowledge and integration of digital technology in teaching and learning. For this purpose, the study explored three key research questions: perception of Maldivian in-service teachers on the constructs of the technological pedagogical and content knowledge (TPACK) framework (*RQ1*), how Maldivian in-service teachers implement technologies in their classrooms and the perceived impact on students' cognitive engagement (*RQ2*), and the factors that influence teachers' technology integration in their classroom teaching (*RQ3*). During phase one, self-reported survey data were gathered from 485 in-service teachers in year levels nine and ten from across the country to understand their perceptions of the constructs of the TPACK framework. In phase two, qualitative data were gathered from nine volunteering teacher participants through semi-structured interviews and document artefacts. The participants for this phase were selected using purposive sampling techniques from three schools located in different regions of the country (capital city versus local island community). The data gathered from both phases were analysed using a tri-theory framework comprising TPACK (Mishra & Koehler, 2006), the substitution augmentation modification and redefinition (SAMR) (Puentedura, 2012), and Bloom's Digital Taxonomy (BDT) (Churches, 2008) as theoretical lenses.

Findings showed that teachers generally had a high perception of TPACK and its related constructs on a five-point Likert scale. The multivariate analysis revealed significant variations in teachers' perception of the TPACK constructs based on their demographic characteristics, especially their teaching subject and nationality (Maldives has a high proportion of expatriate

teachers on working visas). Given that many currently available technology applications are developed to suit the international curriculum, Maldivian teachers (especially those teaching Dhivehi Language and Islamic Studies) had fewer opportunities to adopt these technologies in their subjects.

The qualitative data revealed that having a high TPACK perception did not have any bearing on teachers' frequency of technology use or how they integrated technology in their lessons. In general, teachers typically adopted digital technologies for teacher-centred pedagogical practices of knowledge transmission that supported lower-order cognitive goals. Teachers’ perception of the interconnected TPACK constructs (PCK, TCK and TPK) and several contextual factors influenced teachers' technology integration efforts. This included teachers' beliefs, attitudes and their knowledge regarding TPACK competence at the *micro* contextual level. The professional and emotional support teachers receive from the school leadership, the availability of resources and facilities, time allocation, and professional development training influenced their technology adoption at the *meso* contextual level. At the *exo* contextual level, the support from the parental community was found to be crucial. As for the *macro* contextual level, support from national-level stakeholders in setting the strategic ICT directives, the ICT policies, facilities and resources, and teacher technology professional development training influenced teachers' technology integration endeavours.

This study is timely and significant from multiple perspectives. At the theoretical level, the study adds to the existing literature on TPACK, first, by focusing on in-service teachers at the secondary education level from the context of a small island developing state (SIDS), the Maldives, and second, by offering new insights on TPACK variations based on teacher attributes unique to the local context (subject discipline and teachers' nationality). Third, the study proposed a tri-theory framework comprising TPACK, alongside SAMR and BDT, to investigate how digital technologies are adopted to conduct meaningful learning activities that promote higher-order thinking skills in students. Methodologically, this mixed-methods research study is unique. It combined a robust survey design involving various statistical and thematic analyses based upon a tri-theory framework within one study to explore teachers' TPACK and technology integration in teaching and learning. None of the currently published studies have adopted this methodological approach to investigate teachers' TPACK and technology integration, especially within a SIDS context such as the Maldives. Implications for practice are provided on how the tri-theory framework proposed may be adopted by teachers to transform their pedagogical practices for meaningful student learning using digital

technologies. Recommendations are also included for school leaders and policymakers on targeting resources and training teachers for successful technology implementation.

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List of Abbreviations

AC	Avid College
AVE	Average Variance Extracted
BDT	Bloom’s Digital Taxonomy
BRT	Bloom’s Revised Taxonomy
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
COL	Centre for Open Learning
ECE	Early Childhood Education
EFA	Exploratory Factor Analysis
ESA	Education Sector Analysis
ESP	Education Sector Plan
FIS	Faculty of Islamic Studies
GDP	Gross Domestic Product
GLS	Generalized Least Squares
HDI	Human Development Index
ICT	Information and Communication Technology
ICTMP	Information and Communication Technology Master Plan
IDI	ICT Development Index
IFI	Incremental Fit Index
IPI	Instructional Practices Inventory
IT	Information Technology
ITU	International Telecommunication Union
IUM	Islamic University of Maldives
KMO	Kaiser-Meyer-Olkin
MC	Mandhu College
ML	Maximum Likelihood
MNU	Maldives National University
MoE	Ministry of Education
MQA	Maldives Qualification Authority
NALO	National Assessment of Learning Plan

NCF	National Curriculum Framework
NCIT	National Centre for Information Technology
NFI	Normed Fit Index
NIE	National Institute of Education
OLPC	One Laptop Per Child
PD	Professional Development
PLC	Professional Learning Community
PTA	Parent Teacher Association
QAD	Quality Assurance Department
RFI	Relative Fit Index
RMSEA	Root Mean Square Error of Approximation
SAMR	Substitution, Augmentation, Modification and Redefinition
SES	Socio-Economic Status
SIDS	Small Island Developing States
SMC	Squared Multiple Correlations
SPSS	Statistical Package for the Social Sciences
TLI	Tucker- Lewis Index
TPACK	Technological Pedagogical and Content Knowledge
TRC	Teacher Resource Centres
ULS	Unweighted Least Squares
UNDP	United Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-OHRLLS	United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the
VC	Villa College
WLS	Weighted Least Squares

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature: Aminath Waseela

Date: 01 April 2022

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Chapter 1: Introduction

Governments throughout the world have invested significantly towards the acquisition of technologies for education (George & Sanders, 2017). The goal is to transform teaching and learning through these technologies (Alexander et al., 2013). Research demonstrates that technology integration can positively influence learning outcomes but is contingent on how teachers use technologies in their classrooms (Chandra & Briskey, 2012). As pointed out by Chandra et al., "technology on its own does not make a difference—teachers do" (2014, p. 140). The pedagogical and technical expertise of the teacher has an undeniably critical role here (Gulbahar & Guven, 2008). In other words, the success of technology initiatives in school depends greatly on how teachers make use of these tools in their teaching to support student academic success (Chandra et al., 2014). Thus, it is crucial to ensure teachers have the knowledge and skills required for effective technology integration.

The current study investigated Maldivian in-service secondary grade (grades 9 and 10) teachers' perceptions of the constructs of Technological Pedagogical Content Knowledge (TPACK), perceived impact on teaching and students' cognitive engagement when using digital technologies in classroom environments. It also explored teachers' perceptions of the factors affecting their use of technology in teaching and learning. This chapter begins by introducing the study. It then provides a background to the study (Section 1.1), the research problem (Section 1.2), aims of the research (Section 1.3), research questions (Section 1.4), and the significance of the study (Section 1.5). Next, an overview of the research design (Section 1.6) and the scope of the study (Section 1.7) are presented, followed by a definition of key terms (Section 1.8) and an outline of the thesis (Section 1.9).

1.1 BACKGROUND TO THE STUDY

Information and communication technology (ICT) has affected all aspects of life today, including the education sector. This is evident from the enormous investments governments make in acquiring technologies for the purpose of education (George & Sanders, 2017). These investments are underpinned by the belief that integrating technology in classrooms can positively impact students' engagement and learning outcomes. For example, the past three decades have shown tremendous changes in the design and development of educational technologies. Technologies for teaching and learning have evolved significantly since blackboards first entered the classrooms (EdTech, 2016; Meehan & Salmun, 2016; TeachThought, 2017). This trend has even impacted small island developing states (SIDS) like the Maldives, a nation in the Indian Ocean. Almost ten years ago, the Ministry of Education (MoE) in the Maldives established more than twenty teacher resource centres (TRCs) throughout the country that were equipped with broadband internet connections and a range of other technologies (Li, 2007). A few years later, the Eduframe or mini-laptops for learning program was launched for all students in the third grade of primary school. More recently, the Maldivian government launched the 'Digital school' project where every student in government schools was provided with a tablet. The aim of this initiative was twofold: (1) to enhance students' technological literacy by giving them access to innovative media and (2) to motivate the teachers to use these resources in their classrooms (Ministry of Education, 2017). The project's vision was for schools throughout the Maldives to become innovative and offer quality education to all citizens by enhancing students' technological literacy and exposing them to 21st Century learning (NIE, 2014). However, a recent review done by the Quality Assurance Department has found that a large number of teachers within the system had not been able to help their students achieve the key competencies as outlined in the new curriculum (Quality Assurance Department & UNICEF, 2019).

Literature has shown that the success of technology integration initiatives hinges on the knowledge and skills of teachers to effectively integrate technology in classroom teaching (Chandra et al., 2014). Consequently, gaining an understanding of teachers' technology knowledge and its integration can provide valuable insights on strategies that can be adopted to enhance teaching, especially in developing country contexts such as the Maldives, where research is scant. For this reason, this study focused on understanding how Maldivian teachers integrate technology in their classrooms and the consequential impact on student learning. To date, a review of the literature suggests no published research on how technology is integrated into teaching in secondary schools in the Maldives. Thus, this study investigated Maldivian in-service, lower secondary grade teachers' technological pedagogical and content knowledge (TPACK) and integration in classroom teaching and the perceived impact on students' cognitive engagement. It also explored teachers' perceptions on the factors affecting their use of technology in teaching and learning.

1.2 RESEARCH PROBLEM

Schools across the world have spent heavily on acquiring technologies for the cause of reforming education. Large-scale investments into the acquisition of technologies are often underpinned by the assumption that it can enhance the quality of learning outcomes and student engagement (Chandra & Briskey, 2012; Herold, 2015; Storz & Hoffman, 2013). Likewise, the Maldivian government has been investing heavily in technological initiatives with the aim to enhance students' technological literacy and expose them to 21st Century learning (NIE, 2014). However, current research into how these digital technology initiatives enhance student learning indicates that just the introduction of technology into schools by itself does not automatically improve the quality of education or raise attainment (Chandra, 2020; Chandra & Briskey, 2012). The pedagogical and technical expertise of the teacher undeniably has a critical role here (Gulbahar & Guven, 2008). In other words, the success of technology initiatives in school depends greatly on how teachers make use of those facilities in their classroom teaching (Chandra, 2020; Chandra & Briskey, 2012).

In their seminal work on the knowledge and skills required by teachers to facilitate engaging learning experiences, Mishra and Koehler (2006) argued that in addition to the knowledge of content, technology, and pedagogy, teachers need to have a thorough understanding of the interconnection among the knowledge domains, which they termed as the TPACK (technological pedagogical content knowledge). Since the introduction of the TPACK framework by Mishra and Koehler (2006), this model has been at the forefront of investigating teachers' integration of technologies in teaching and learning. The model purports that teachers should be able to choose appropriate technology and adopt appropriate pedagogical practices to teach the content of their subject. A more detailed discussion on this model is provided in the next chapter (see Section 2.5.1). Further, Harris and Hofer (2009) posited that to integrate technology effectively, teachers must consider their pedagogical practices based on the curriculum requirements as well as the affordances and constraints of the available technology. Therefore, teachers need to have the knowledge and skills to plan and teach effectively using technology.

Research on teachers’ TPACK and knowledge for technology integration is prevalent, yet lacks adequate identification on the specific types/ ways it can enhance pedagogy and student engagement (Casamento, 2017). Thus, given the influence of technology on the teaching and learning process, it has become more important to empirically examine the competencies required of teachers to incorporate technology successfully into their instruction

(Mishra & Koehler, 2006). Besides, much of the existing research has focused on pre-service teachers' use of technology while still undergoing training. Therefore, the frameworks adopted in analysing the problem and recommendations provided for those contexts may not necessarily apply to the technology use context for most teachers currently in practice. Subsequently, research on teachers' knowledge, how they integrate technology, and the perceived impact on student's cognitive engagement within the SIDS context such as the Maldives is scant. Only a few studies have been conducted in the Maldives exploring teachers' integration of technology in teaching and learning (Adam, 2015; Ali, 2015; Kinaanath, 2013; Shameem, 2016).

The few studies conducted thus far in the Maldives on teachers' technology integration had either focused on teachers' use of technology in pre-service teaching or higher education (Adam, 2015; Kinaanath, 2013). Although Shameem (2016) and Ali's (2015) study targeted secondary education teachers, the focus of these studies has been to explore the factors influencing teachers' technology adoption, and both studies were conducted as surveys. The only research that had touched on teachers' TPACK was conducted by Adam (2015), but the focus was on investigating how teacher educators form their pedagogical and technological practices through a cultural habitus lens. Thus, the study was narrow and ethnographic in nature, with only 12 teachers, which meant that the study had a small sample size, and its findings not generalizable.

As evidenced, large-scale studies on teachers' technology integration and its impact on students' learning and engagement have not been investigated in Maldivian school contexts. Besides, no studies have explored in-service teachers' technology integration (at any year level) within the Maldivian school context. Furthermore, the key findings reported in the Education Sector Analysis 2019 report (ESA 2019) produced by the Ministry of Education have highlighted the need for empirical evidence on ICT implementation in Maldivian schools. Consequently, to meet these needs, the report has recommended:

- Conducting an analysis of current practice on ICT integration in teaching and learning
- Conducting an impact evaluation regarding the use of ICT to improve learning and decrease the learning gap in the country
- Training all teachers in "ICT literacy and ICT pedagogy-integration
- Assisting all schools to develop their own ICT in education development plans

(Ministry of Education, 2019, p. 183)

The above gaps in the literature indicate a real need to investigate Maldivian in-service teachers' knowledge and integration of technology in classroom teaching, and how it impacts student engagement at a national level.

1.3 AIMS OF THE STUDY

Considering the issues identified above and the limited literature within the Maldivian school context, identifying issues surrounding teachers’ knowledge and use of technology is imperative to facilitate better alignment between what is taught and how it is taught, particularly when adopting digital technologies. Moreover, recognizing and addressing the crucial factors shaping teachers’ competence in their technology integration efforts can help achieve maximum educational gains when introducing technology implementation initiatives. Thus, this study aimed to investigate Maldivian in-service teachers' TPACK, how technology is integrated into classroom teaching, and the perceived impact on students' cognitive engagement. The study also identified the factors affecting teachers’ use of technology in the different classroom and school contexts.

1.4 RESEARCH QUESTIONS

To achieve the aim as mentioned above, the study explored the answer to the following research questions:

RQ1: What are Maldivian in-service teachers' perceptions of the constructs of TPACK (Technological Pedagogical and Content Knowledge)?

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

The targeted group of teachers in this study were grade 9 and 10 teachers. In order to address these three research questions, this study applied an explanatory mixed-methods case study design. The quantitative data were gathered through an online survey, while the qualitative data were gathered through semi-structured interviews and document artefacts.

1.5 SIGNIFICANCE OF THE STUDY

The literature claims that effective technology integration in education can transform the teaching and learning processes. Despite these claims on the transformation of pedagogy, there is limited evidence to support wide-scale change in pedagogy (Ertmer & Ottenbreit-Leftwich, 2013; Zheng et al., 2016). The reviewed literature also indicates that schools across the globe have been investing heavily in acquiring technology tools for educational purposes. However, the literature on how teachers' integration of technologies facilitates the transformation of pedagogy and student engagement, especially in small island developing country contexts is scarce. Thus, understanding how teachers integrate digital technologies effectively in their practices is where the proposed study became significant. More specifically, the findings from this research have significant implications for both theory and practice.

1.5.1. Practical significance

Studies on technology integration in teaching and learning underpinned by theoretical constructs in the developed world are ample. However, similar studies within SIDS such as the Maldives, are scarce, although teaching with technology in classrooms in SIDS schools is on the rise. Thus, this research was timely in that the Ministry of Education in the Maldives has been investing heavily in enhancing technology integration into schools by digitizing the curriculum and providing digital technologies across the whole country. The investigation of teachers' perceptions of TPACK and how they integrated technology in classrooms in this study has shed light on in-service teachers' ability and preparedness towards technology integration. The proposed recommendations based on this study's findings directly link to the recommendations identified in the ESA 2019 report as mentioned earlier. In this regard, the recommendations can be highly relevant to teachers who need guidance on technology integration. It can also be valuable for school leaders and policymakers considering creating more technology-based learning environments. That is, in an era when technology is at the forefront, and the global pandemic has almost forced all teachers to switch to teaching online, equipping appropriate knowledge and skills to conduct learning activities in meaningful ways to engage students and produce citizens with the capabilities as aspired in the new national curriculum is crucial.

The findings from this study have indicated that despite having a high perception of the constructs of the technological and pedagogical content knowledge, most participants had adopted technologies to enhance their pedagogical practices to foster traditional drill and practice style of teaching. As Mishra and Koehler (2006) argued, to conduct effective technology-based teaching and learning activities, teachers need to understand not only the content, pedagogy, and technology, but also the interconnections between these knowledge domains. This study has found that teachers lacked appropriate knowledge and skills in linking technology knowledge with the content and pedagogy for student-centred constructivist-oriented teaching. Their technology integration efforts were also influenced due to other contextual factors. Thus, based on the teacher perceptions identified in this study, schools and teacher training institutions may choose to alter their mandated teacher orientation and professional learning opportunities for technology integration. Finally, since teachers are tasked with technologies to guide students in developing 21st-century skills, a thorough understanding of teachers' technology knowledge and skills can help policymakers decide where and how to source support.

1.5.2. Theoretical and methodological significance

Another significance of this study is its contribution to TPACK literature, how it is translated into pedagogical practices when integrating technology for teaching and learning activities, and the factors influencing these efforts. From the reviewed literature, it can be concluded that there has not been any published work that has explored teachers' TPACK and technology integration in classroom teaching, especially within a SIDS context such as the Maldives.

Moreover, no published work had adopted the tri-theory framework (combining TPACK, SAMR, and Bloom's Digital Taxonomy (BDT)) to examine in-service teachers' knowledge and integration of technology in their classroom environment, especially in a SIDS context. The use of TPACK in this study allowed the researcher to examine teachers' perceptions of TPACK concerning how digital technologies are adopted for meaningful learning activities and foster higher-order thinking skills in students. The SAMR model developed by Puentedura (2012) guided the evaluation of how teachers integrated technology in their teaching and learning, while Bloom's Digital Taxonomy developed by Churches (2008) aided in understanding the impact on students' cognitive engagement. Thus, the use of TPACK, SAMR, and BDT as theoretical lenses within a single study was methodologically novel and offers a deeper understanding of teachers’ knowledge and skills for technology integration.

Theoretically, the findings from this research and the proposed tri-theory framework have made significant contributions to the TPACK literature and literature on technology-enabled education through the lens of SAMR and BDT. Also, this research is novel in that it contributes to the literature on technology adoption research by developing an understanding of teachers’ technology integration within a SIDS context. More details on the implications of these findings and recommendations that came about as a result of this study can be found in the conclusion chapter (see Section 7.3).

1.6 OVERVIEW OF RESEARCH DESIGN

This research adopted a pragmatic approach and an explanatory mixed-methods case study design to explore the inquiry (Yin, 2014). It used surveys, interviews, and document artefacts to gather the data from a sample of in-service teachers teaching in grades 9 and 10 of government schools in the Maldives. The study was entailed in two phases (see *Figure 1.1*).

Phase 1 aimed to ascertain in-service teachers' understanding of technological pedagogical and content knowledge (TPACK) required for technology integration. Quantitative data were gathered using the TPACK survey questionnaire adapted from Koh et al. (2013). It was administered to teachers nationally and provided a macro level or global picture of teachers' perceptions across the constructs of the TPACK survey. The analysis of responses from phase one fed into the second phase, the micro-level qualitative case studies.

Micro-level case studies helped gather qualitative data for phase two of the study. The aim was to understand how in-service teachers integrate technology, the perceived impact on students' cognitive engagement (through the teachers' lens), and the factors influencing technology use. Data for this phase were gathered using semi-structured interviews and document artefacts (e.g., lesson plans, assessment tasks, students' work) from nine volunteering participants from three schools across the country. The SAMR (Puentedura, 2012) and BDT (Churches, 2008) frameworks guided understanding of how technology was integrated and its impact on teaching and students' cognitive engagement. The model proposed by Porras-Hernández and Salinas-Amescua (2013) was adopted to evaluate the factors that influenced teachers' technology integration efforts in the Maldives. Further discussion of the research design, the philosophical underpinnings, and the methods adopted in investigating the research questions can be found in the methodology chapter (see Section 3.3).

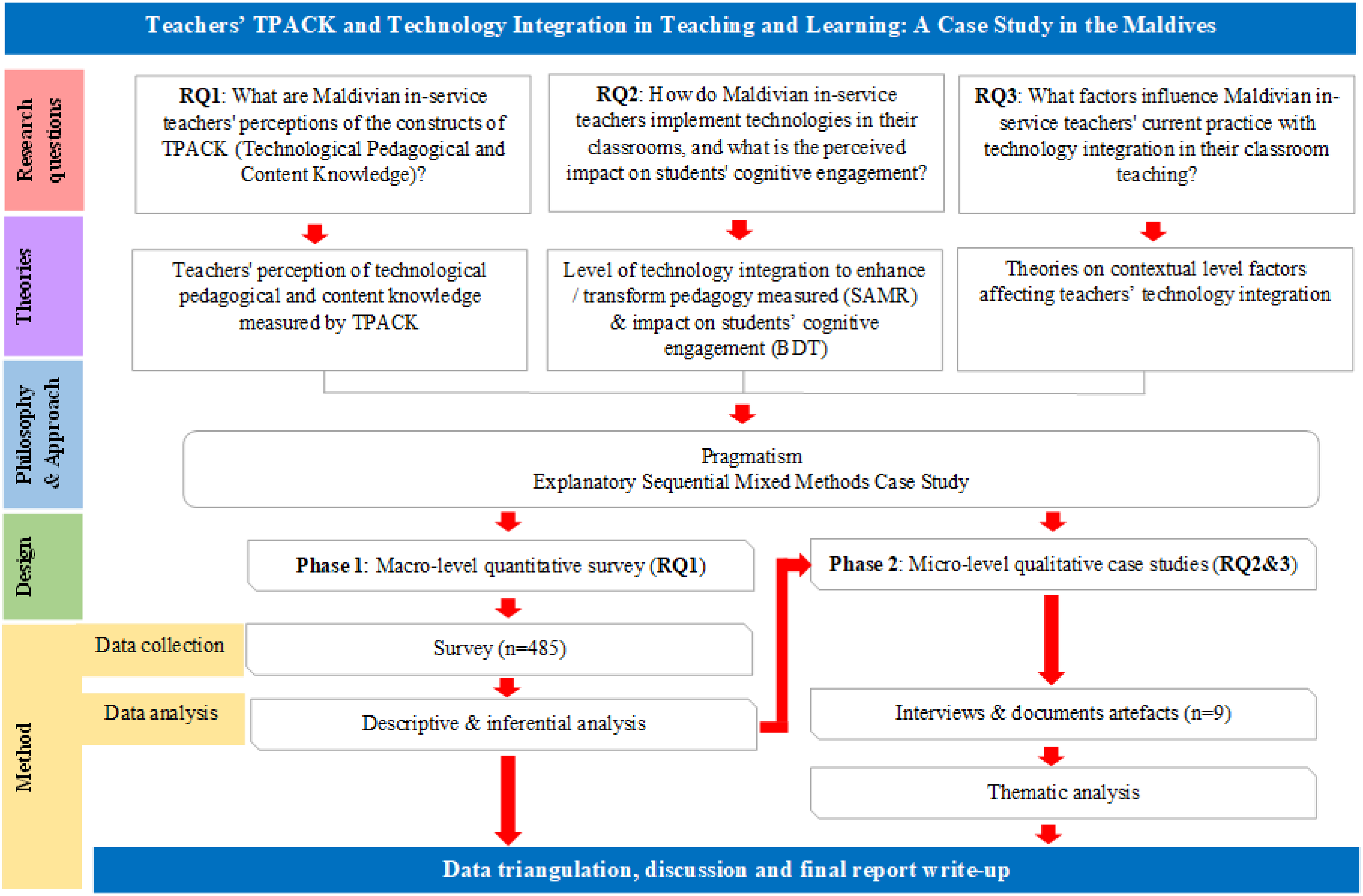


Figure 1.1: Research design overview

1.7 SCOPE

This study aimed to gain a national snapshot of teachers' self-assessment of their TPACK, technology use, and factors that influenced their technology integration efforts in their teaching. Thus, the study was bounded by the three research questions (see Section 1.4) it proposed to answer and by its target population. The population was limited to in-service teachers teaching in grades 9 and 10 of government schools in the Maldives since all the teachers belonging to this category have had access to similar types of training (undergraduate degree in their specific subject discipline). Thus, to investigate teachers' perception of the TPACK constructs (phase one), survey data were gathered from all volunteering in-service teachers teaching in grades 9 and 10. The study did not include teachers from other grade levels, non-governmental nor pre-service teachers.

Since the second and third research questions required more in-depth investigation, the sample was limited to nine participants identified using purposeful sampling. This selection was thus bounded by two criteria: the teacher's score on the TPACK perception survey and the geographical location of their schools. The aim was to capture differences (if any) in how teachers implement technology in their teaching based on:

(a) their level of understanding of the TPACK constructs (teachers with either average, high, or very high mean scores on the TPACK scale); and

(b) the differences in school contexts (urban versus rural, since the types of technology devices and support available differs among the regions)

Furthermore, this study's scope is constrained by the proposed research design and theoretical presuppositions. The research design proposed was an explanatory mixed-methods case study design to identify teachers' TPACK perception, technology use, and the impact on their students' cognitive engagement. The scope of this study was also bounded by the three theoretical presuppositions TPACK, the Digital Bloom's Taxonomy, and SAMR model. TPACK theory by Mishra and Koehler (2006) provided a lens to examine teachers' TPACK knowledge. The SAMR model by Puentedura (2012) provided a lens to examine how teachers use technology in their teaching and the two forms of change: enhancement or transformation it brought to student learning. Bloom's Digital Taxonomy by Churches (2008) provided a lens to explore the impact of teachers' technology use on students' learning engagement in terms of their cognitive achievement at the levels of Bloom's digital taxonomy.

1.8 DEFINITION OF KEY TERMS

This section aims to define some of the key terms that were used in this study. The reason for defining these terms is to reduce confusion that might arise as the exact terms could mean different things in other contexts. Thus, it was necessary to define necessary:

Information and Communication Technology (ICT): ICT is defined as hardware (computers, radio, television, tablets, iPad, and mobiles, etc.) and software applications (internet facilities such as websites, blogs, and emails, etc.) that work together in unison to make it possible for data to be transmitted to anyone at any place in the world where the signals can be received (UNESCO, 2018a).

Digital technology: Refers to technology resources (hardware and software) used to generate, store, or process data. Hardware devices include computers, tablets, smartphones and the like. Software technologies include programs, apps, cloud-based solutions and incorporate Information and Communication Technologies (ICT).

Technology integration: Technology integration is the use of any technology, both hardware, and software, for instructional purposes (Davies & West, 2014). This research used **ICT**, **IT** (Information Technology), **technology**, and **digital technology** interchangeably as all these terms are commonly used in the Maldives and around the world to mean the same thing.

In-service training: These are short awareness programs conducted to inform practicing teachers about new ideas (Bellanca, 1995).

Technology professional development training: Training given to teachers to enhance teachers' professional knowledge and skills on the use of technology tools (e.g., interactive whiteboards, tablets or learning management systems) to improve teaching effectiveness and student performance.

Small Island Developing States (SIDS): A distinct group of 52 developing countries recognized as special cases due to similar kinds of social, environmental, and developmental vulnerabilities (UN-OHRLLS, 2011). More detail discussed in chapter two (see Section 2.3).

Classroom Practices: Classroom practices refers to instructional strategies and techniques used by the teacher to deliver the designed curriculum (Cole, 2012)

Student engagement: Student engagement is defined as the level of students' involvement in their learning through cognitive investment, active participation, and emotional engagement (Chapman, 2003). Active participation and emotional engagement are both contributors to and results of the cognitive investment. This means that student cognitive engagement is the ultimate goal of instruction.

Student cognitive engagement: Student cognitive engagement is defined as “the deliberate task-specific thinking that a student undertakes while participating in a classroom activity” (Helme & Clarke, 2001, p. 136). The six levels of the bloom’s digital taxonomy is used to assess the perceived level of students’ cognitive engagement in this study.

1.9 ORGANIZATION OF THIS THESIS AND CHAPTER SUMMARY

This thesis is organized into seven chapters. This chapter provided the background overview to this thesis, including the research problem, research aims, and research questions. It also outlined the significance, the theoretical and methodological contributions of the study. This was followed by a brief overview of the research design, the scope, definition of key terms frequently used in this study. It concludes with an overview of how the thesis is organized (see *Figure 1.2*). In the following chapter, a review of the literature relevant to this research study is discussed.

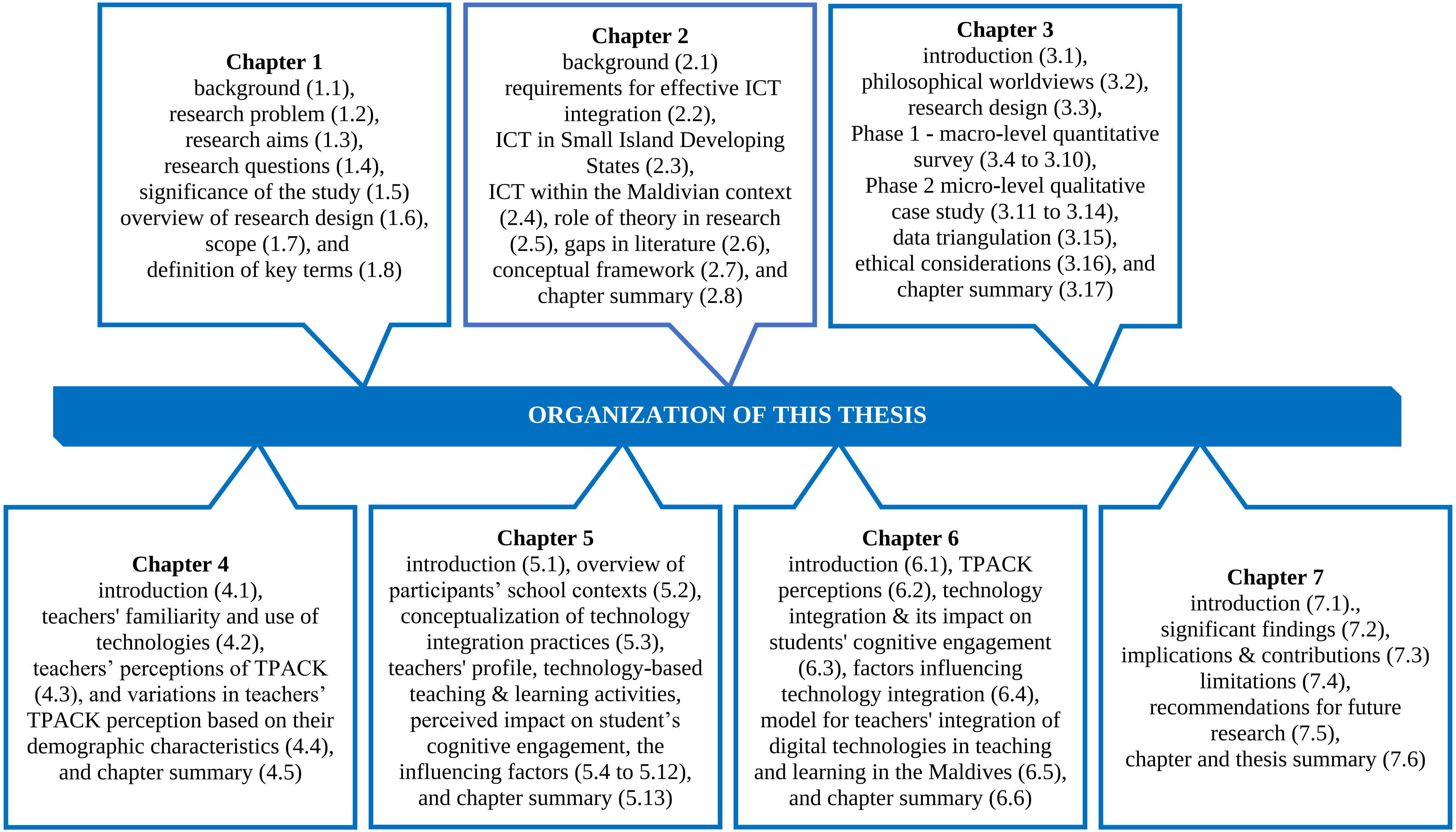


Figure 1.2: Organization of the thesis

Chapter 2: Literature review

The purpose of the current study is to gain an in-depth understanding of teachers' knowledge and practices of using technology, its impacts on students' cognitive engagement, and the factors affecting teachers' use of technology in the classroom. This chapter will review each of the strands relating to the research aims mentioned in chapter one. This review will therefore begin by giving a background on ICT in education (Section 2.1); requirements for effective ICT integration (Section 2.2); ICT in education in Small Island Developing States (SIDS) (Section 2.3); technology integration in the Maldivian context (Section 2.4); the role of theory in research (Section 2.5); the gaps in literature (Section 2.6); the conceptual framework for the study (Section 2.7). Finally, the chapter concludes with a brief summary of the literature presented in this review (Section 2.8).

2.1 BACKGROUND TO ICT IN EDUCATION

The rapid advancements in information and communication technology (ICT) have led to an increase in its uptake in all works of life, including the education sector (Al Harbi, 2014). Ever since the first computer was introduced in the classroom, technology is found to have become indispensable and will continue to be a key player in future classrooms too (Al Harbi, 2014). Interestingly, despite ICT being a widely used term when referring to technology in education, the literature indicates no globally accepted definition to describe ICT. Thus, defining ICT and technology integration within educational contexts is critical to this study.

According to Chunfang (2017), ICT is a set of information technology tools that can be chosen to support the education environment in developing and fostering ideas through learner stimulation by engaging them in deeper learning processes and activities. Likewise, ICT is defined by UNESCO (2018a) as a diverse set of technological tools and resources that are used for processing information and communication. It includes hardware and software applications that work together to transmit data to anyone at any place in the world where the signals can be received. Some of the hardware includes computers, radio, television, tablets, iPad, and mobiles. Computer applications and internet facilities such as websites, blogs, and emails are just a few software applications (UNESCO, 2018a).

In addition, as mentioned earlier, how technology integration in education is defined is also significant to this study. According to Kimmons (2020), technology integration in education is the “the meaningful implementation of technology in educational settings to achieve learning goals” (p. 3). Similarly, Davies and West (2014) defines technology integration as the effective implementation of educational technology tools such as computers, mobile devices, and interactive whiteboards to accomplish intended learning outcomes. This definition recognizes that “teachers are on a continuum of integration practices, which may or may not coincide with the literature on best practice” (Yankelevich, 2017, p. 9).

The above examples show that there is no unified definition for ICT or technology integration. Thus, considering the various terms and accompanying definitions, this study adopts the definition provided by UNESCO (2018a) to define ICT. The main reason is the prevalence of studies conducted by UNESCO on ICT in education in developing country contexts with characteristics similar to the Maldives. Correspondingly, the definition provided by Davies and West (2014) is adopted in this study to define technology integration in teaching and learning. Moreover, within the reviewed literature, the terms ICT, IT, technology, and digital technology were used interchangeably in different contexts when discussing technology in education. The terms commonly used in the Maldives; the context for the current study also comprises terms such as IT, ICT, technology, or digital technology. Thus, these terms will be adopted interchangeably when discussing technology integration by in-service teachers in Maldivian schools.

2.1.1. The benefits of digital technology in education

Digital technology is regarded as a valuable enabler that can be utilized to support learners to acquire, share and distribute knowledge at little cost (Mukhari, 2016). New technologies have also been shown to enable new ways of thinking in education and new learning cultures. One of the main aims of integrating technology into the curriculum is increasing student engagement and transforming learning by developing 21st-century essential life skills for all students. Digital technologies benefit teaching and learning in a number of ways. ICT offers new tools that can add value to traditional learning modes and may be achieved by offering lessons in various digital media forms or through virtual learning experiences (Jones & Dexter, 2018). This allows learners to attribute meaning to learning content through their own exploration and discovery (Lehtinen, 2010; Mukhari, 2016).

Furthermore, research suggests that equipping students with a computing device makes schoolwork more exciting and engaging, motivating students to work harder and learn more (Chalmers et al., 2014; Chandra & Briskey, 2012; Clarke, 2016; Geelan et al., 2014; Varier et al., 2017; Zheng et al., 2016). For example, an investigation carried by Chandra and Briskey (2012) to study the impact of ICT on learning outcomes of high school mathematics students, found that use of technologies such as web-based applications had a positive impact on students and their learning outcomes. They found student exposure to web-based digital applications enabled an engaging experience for the majority of the students. The researchers identified the instant feedback function within web applications as one of the key benefits of using technology. They also believed that this function of the web application facilitated scaffolding of students' learning and sustained engagement. Moreover, the researchers reported that students enjoyed the experience with the web application as it was interesting for them (Chandra & Briskey, 2012).

Similarly, a study done by Chalmers et al. (2014) examined the value of the 'Robotics@QUT program' for pre-service teachers and students participating in the program. The aim of this program was to help build students' study aspirations towards STEM (Science, Technology, Engineering and Mathematics) for students from low socio-economic status (SES). Their study found increased student engagement and motivation following the implementation of the robotics activities in classrooms (Chalmers et al., 2014).

In another study, Clarke (2016) investigated the relationship between different types and frequencies of laptop usage and student reading achievement, the barriers, and opportunities which limit or promote the use of the laptops by students and teachers. This study reported increased student engagement in writing tasks when they were provided with more efficient and engaging means of research using laptops. He also found that student attendance improved as a result of enhanced engagement (Clarke, 2016), and were found to be more responsible for their own learning. Thus, it resulted in increased student motivation with their writing tasks, allowing them to produce work that demonstrated better quality outputs (Clarke, 2016). However, Clarke (2016) advised taking precautions when considering these effects as there could be other factors such as ability grouping at the school, and teacher decisions regarding assignment of homework that impacts student achievement.

In a meta-analysis conducted by Zheng et al. (2016), they examined the effect of one-to-one laptop programs on teaching and learning in K–12 schools. This review comprised 65 journal articles and 31 doctoral dissertations published between January 2001 and May 2015. The analysis provided further evidence on improvements in student engagement and enthusiasm towards learning in all subject areas as a result of technology use. They found that use of laptops facilitated more student-centred, individualized, and project-based instruction.

In addition, technology use was found to enhance the teacher-student, home-school relationships with significant positive achievement outcomes in English, writing, mathematics, and science (Zheng et al., 2016).

Similarly, Varier et al. (2017) examined the implementation of six technology devices in 18 elementary, middle, and high school classrooms. The purpose of their investigation was to get an understanding of teachers' and students' experiences related to the instructional implications of the one-to-one devices. The aim was to identify an appropriate technology device that would help the district achieve its strategic goals of creating a 21st-century learning environment (Varier et al., 2017). They reported positive impacts regarding student engagement and motivation towards learning. For instance, students were found to show more interest and focus on the learning tasks after the implementation of technology (Varier et al., 2017). They also found that technology enhanced students' capabilities to collaborate and solve problems. Additionally, technology devices were reported to support students' self-directed learning; promote communication and collaboration with teachers as well as peers; and increase students' use of immersive technology tools to produce, organize, and share academic work (Kucuk, 2018; Varier et al., 2017).

Interestingly, not all technology initiatives result in benefits the way it is intended as evidenced by the quasi-experimental study done by Geelan et al. (2014) on the effectiveness of computer-based scientific visualizations for concept learning. The investigation was conducted with 80 Year 11 physics students in Australian classrooms to model visualisations using freely available online sources to help students learn chemistry concepts and found no significant differences for teaching with and without the technologies. They believed that the way teachers used such applications and the degree of interactivity available to students may have affected the learning gains from using such tools. However, given the study's limitations and the extensive literature covering the learning and engagement benefits students enjoy with such tools, they still supported using visualisation software for student learning (Geelan et al., 2014).

The findings in the studies discussed above points to several benefits of using technology in teaching and learning. Almost all the studies indicated that there was an enhancement in student engagement with technology integration. Thus, high levels of student engagement through the use of digital technologies may pay real dividends in terms of student achievement. Although these studies depict a common theme that "technology is beneficial to the classroom, the question is raised as to whether or not there is an educational advantage based on student achievement" (Clemensen, 2018, p. 23). It is therefore imperative that the literature on student engagement and achievement be explored in order to understand how engagement is enhanced, which follows next.

2.1.2. Student's (cognitive) engagement

Student engagement, its causes and effects have been widely studied within different contexts over the past two or more decades (Dennis, 2013; Fredricks et al., 2011; Garwood, 2013; Glaman & Chen, 2018; Reschiglian, 2017; Skinner & Belmont, 1993; Valentine & Collins, 2011). Admittedly, as seen from the discussion on the previous section, student engagement has been reported within literature as one of the main benefits of ICT implementation initiatives. However, one major issue with student engagement as a construct is the numerous variations across research studies on how the term is defined and measured (Fredricks et al., 2011). While some of the early studies adopted observable behaviours such as time on task and participation to define the term (Brophy, 1983; Marzano, 2007), other studies included affective factors such as enjoyment into their definition of engagement (Connell, 1990; Marks, 2000). Some other researchers coined cognitive engagement such as the students' investment in learning, learner self-regulation and perseverance, and the use of deep learning strategies into their definitions (Fredricks et al., 2011; Fredricks et al., 2004). The notion of cognitive engagement is also evident in Helme and Clarke's definition of student engagement which involves "the deliberate task-specific thinking that a student undertakes while participating in a classroom activity" (2001, p. 136). Interestingly, amongst all these definitions, three broad categories: cognitive, behavioural, and emotional or affective factors seem to appear consistently, though researchers contend that all three types of student engagement affect student learning (Appleton et al., 2008; Burch et al., 2015; Fredricks et al., 2011; Sinatra et al., 2015).

It is evident from the preceding discussion that there is no simple way to define or measure student engagement due to the multidimensional constructs it encompasses. However, almost all studies included cognitive, behavioural, and emotional or affective factors in conceptualizing student engagement. Moreover, literature indicated the enhancement in student engagement with technology integration. Thus, student engagement through technology integration might be vital to realize better student achievement. However, since teachers are at the crux of classroom teaching, an important question one should raise is, how can teachers integrate these technologies effectively and what issues or challenges do they face in integrating technology in their classrooms.

Since the focus of the current study is on the cognitive aspect of student engagement, the definition this study adopts is that proposed by Helme and Clarke (2001). This definition implies that students are required to apply their cognitive thinking skills in order to accomplish classroom activities. To develop classroom activities that require students' application of their cognitive thinking skills, teachers often adopt the famous taxonomy developed by Bloom and Krathwohl (1956). This taxonomy describes six levels of cognitive thinking that range from lower-order to higher-order thinking skills. The original Bloom's taxonomy was later revised by Anderson, a former student of Bloom to address the requirements of 21st-century learning (Anderson et al., 2001). Consequently Churches (2008) updated Bloom's Revised Taxonomy to create the Bloom's Digital Taxonomy (BDT) to incorporate new ways of learning facilitated by technology. Although the taxonomy has been reviewed a few times, the basic premise- development of students' cognitive or higher-order-thinking skills is still maintained.

Educators as well as researchers uphold the value of higher-order thinking skills for student learning (Anderson et al., 2001; Bloom & Krathwohl, 1956; Dennis, 2013; Fredricks et al., 2011). Higher-order thinking, or deeper learning, requires a high level of cognitive engagement, and thus, to develop higher level thinking skills, scholars believe that it is important to adopt more student-centred teaching approaches (Dennis, 2013). This type of teaching approach encourages students to collaborate with others and engage in more experiential learning that is authentic and challenging (Dennis, 2013; Jones, 2007). It is also found to promote more active learning that encourages exploration, skill development, and students' construction of their own learning (Dennis, 2013). More importantly, research demonstrate a strong link between student engagement in their classroom activities and their academic performance (Charleston, 2017; Swayne, 2017).

Undoubtedly, there exists a myriad of noteworthy factors that impact on student engagement. Amongst these, technology use and how it is integrated by teachers is reported to be an important factor affecting students' engagement and academic achievements (Charleston, 2017; Kim et al., 2016; Swayne, 2017; Zheng et al., 2016). For example, in an article published on the use of iPad in a Chicago public school, teachers' ability to differentiate instruction and provide students with opportunities to be creative resulted in increased student engagement and student achievement (Heaton, 2013). Similarly, Kim et al.'s (2016) study on fostering creativity in tablet-based interactive classrooms found that technology centred classroom instruction was positively associated with better student performance and engagement (Kim et al., 2016). Additional examples of these engagement benefits were discussed in the preceding section (see

Section 2.1.1). In such technology rich environments, teachers act as facilitators that create opportunities for students to engage in activities that promote higher-order thinking skills (Heaton, 2013). Thus, finding ways to assess cognitive engagement is key to enhancing student learning. One measure that is found in literature that can be used to measure cognitive engagement is Bloom's Digital Taxonomy (BDT) by Churches (2008) and it is proposed as a way to assess students' cognitive engagement for the current study. This measure of interest has been used in empirical research and taps into dimensions of cognitive engagement that might predict important outcomes (Glaman & Chen, 2018). More details on this model are discussed later in this chapter (see Section 2.5.2).

2.1.3. The barriers to technology integration

Barriers to technology integration are "obstacles which prevent or inhibit teachers from adopting and integrating digital technologies into teaching and learning activities" (Lawrence & Tar, 2018, p. 96). Many of these barriers persist not for teachers' lack of trying but because of the overwhelming nature of the technology (Plair, 2008). The literature on barriers to technology integration span a wide range of contexts (Chandra et al., 2014; Dalrymple, 2017; Ertmer, 1999; Hew & Brush, 2007; Hsu, 2016; Kilinc et al., 2018; Koehler et al., 2013; Lawrence & Tar, 2018; Neira et al., 2018; Nykvist, 2013; Plair, 2008; Tachau, 2017). Over the years, various authors have used a multitude of ways to explain these barriers. For instance, Ertmer (1999) uses the terms 'first-order' and 'second-order' barriers to explain the institutional and personal factors or barriers, respectively. The 'first-order' or institutional factors included barriers related to technology resources, support, and training, while the personal barriers included factors such as teachers' attitudes and beliefs, knowledge, and skills (Ertmer, 1999). In a later study, Ertmer and Ottenbreit-Leftwich (2013) grouped these as barriers internal or external to the teachers. Internal barriers (considered as second-order barriers) included teachers' attitudes, beliefs, knowledge, skills, and technology self-efficacy. The external barriers (which were considered first-order barriers) included technology support, state standards, money, technology access and time, and beliefs of other teachers (belief of peers).

Similarly, a study conducted by Wachira and Keengwe (2010) also found several internal and external barriers preventing teachers from integrating technology. These barriers included the unavailability and unreliability of technology, lack of technical support, poor technology leadership, anxiety and lack of confidence in using technology, classroom management issues related to technology use and lack of time for planning, especially for technology integration (Afshari et al., 2009; Belland, 2009; Ertmer & Ottenbreit-Leftwich, 2012; Francom, 2020);

Kopcha (2012); (Tachau, 2017; Wachira & Keengwe, 2010). In a more recent case study, Lawrence and Tar (2018) categorized the barriers to technology integration at teacher-level and institutional-level barriers. They identified the lack of ICT knowledge, lack of time, resistance to change, and difficulties in integrating ICT as teacher-level barriers, while issues with infrastructure, training, access and lack of technical support were identified as institutional barriers.

The reviews above portray the numerous technology integration challenges faced by teachers in more affluent societies. As one would imagine, the situation is more profound in less developed nations, as they have their own unique sets of characteristics that may not be observed in developed countries. An excellent example of such challenges can be drawn from Chandra et al.'s (2014) work on the technical capacity building project they conducted in Fijian schools under the Share, Engage and Educate (SEE) initiative. Besides technological resources and lack of qualified teachers, they found the importance of considering the financial, technological, physical, and logistical resources as critical barriers to implement technology in schools successfully. They further argued on the importance of the capacity building of the ICT teacher champions in schools for successful technology integration.

In summary, this section of the literature has identified several benefits that support the use of technology in teaching and learning. This includes enhanced student engagement and motivation, positive achievement outcomes, foster learning through exploration and discovery, self-directed learning, promote communication and collaboration, problem-solving, and project-based learning activities) (Chalmers et al., 2014; Chandra & Briskey, 2012; Clarke, 2016; Geelan et al., 2014; Jones & Dexter, 2018; Lehtinen, 2010; Mukhari, 2016; Varier et al., 2017; Zheng et al., 2016). Another critical finding portrayed from the above review was the extensive coverage of literature on various barriers or factors related to technology integration (Chandra et al., 2014; Dalrymple, 2017; Ertmer, 1999; Hew & Brush, 2007; Hsu, 2016; Kilinc et al., 2018; Koehler et al., 2013; Lawrence & Tar, 2018; Neira et al., 2018; Nykvist, 2013; Plair, 2008; Tachau, 2017). This includes issues pertinent to teachers, the implementing authorities both at institutional and national levels. Thus, these barriers can be summarized into teacher-level factors internal to teachers and institution-level or external factors. Considering the enormous impact these factors can have on teachers' technology integration efforts, both in developed and developing societies, a closer examination of the requirements of successful technology integration becomes crucial. Therefore, these crucial factors are explored in more detail next.

2.2 REQUIREMENTS FOR EFFECTIVE ICT INTEGRATION

The reviewed literature revealed that there are several requirements or factors necessary for the effective incorporation of technology in the classroom. Some of these factors were briefly discussed under 'barriers to technology integration' in the preceding section (see Section 2.1.3). However, as mentioned in the previous section, there is an enormous body of literature on the factors affecting teachers' technology integration in different contexts. Moreover, as these studies accentuate the significant impact these factors can have on successful technology integration, a separate section elaborating the factors in more detail is necessary. Thus, this section of the review explores these key factors in more detail.

There are a variety of ways in which these factors or requirements to technology integration are classified. For instance, Porras-Hernández and Salinas-Amescua (2013) categorize these into three contextual levels: micro, meso, and macro level factors. Likewise, Neira et al. (2018) adopts a similar categorization, but uses slightly different terminologies: microsystem (factors internal to the teachers), mesosystem (factors that lie within the institution), and those at the national/international level (macrosystem). In addition, Neira et al. (2018) introduced a fourth level called the exosystem (factors that lie between institutions). Despite the variations in terminology, the contextual levels identified by these authors suggest that teachers' technology integration efforts can get influenced in a multitude of ways, and often these factors are intertwined.

For instance, the micro contextual level factors described by Porras-Hernández and Salinas-Amescua (2013) are similar to the microsystem related to teachers identified by Neira et al. (2018). This includes teachers' beliefs and attitudes, expectations, and preferences towards teaching with technology, as well as their technological knowledge and skills. It is also concerned with in-class conditions for learning such as the availability of technology resources, norms, and policies, the school's commitment to the implementation process, and the availability of technical support. It can also include teacher-related factors such as gender, subject discipline, grade level, class size, age or teaching experience, and experience with technology (Afshari et al., 2009). According to Porras-Hernández and Salinas-Amescua (2013), teachers feel most comfortable at this context level as they perceive greater independence, and thus, mutual expectations become very important.

At this micro contextual level, teachers need the pre-requisite competencies to integrate technology, motivation to adopt technology in teaching; high level of self-efficacy;

metacognitive skills to choose appropriate technology tools, and the ease of use of technology (Barnes & Kennewell, 2017; Neira et al., 2018; Park & Ertmer, 2008; Zyad, 2016). For technology integration to succeed, teachers need to be supported with adequate time and access to digital infrastructure and resources at the institutional level. For example, teachers need a space for them to collaborate to help disseminate good practices and reflect and provide feedback on new technology applications (Eickelmann, 2011). In addition, teachers need support from a qualified technician and an ICT plan that clearly identifies its vision for technology integration (Kafyulilo et al., 2016).

The next contextual level, which is termed as the meso level (Porras-Hernández & Salinas-Amescua, 2013) or the mesosystem level (Neira et al., 2018) is related to the connections between teachers, peers, the school management, parents, and the wider local community and how these demographics impact teachers' use of technology in their practices (Roussinos & Jimoyiannis, 2019). At this level, the social, cultural, political, organizational, and economic conditions established within the educational institutions can largely affect teachers' uptake and use of technology. Here, as Porras-Hernández and Salinas-Amescua (2013) identified, the role of supportive peers with expertise in using technologies to transform students' learning and who are willing to share their experiences can be beneficial. Besides, Roussinos and Jimoyiannis (2019) believe that appreciation of teachers' professional work with ICT by the students, their parents, the superiors, and other peers in the school positively impact teachers' perceptions of ICT integration. Contrarily, teachers' technology adoption with their students can be adversely impacted when faced with parental unwillingness (often due to parent's fears of their children being exposed to inappropriate content or sometimes due to parents' own technological illiteracy), as reported by McClure and Pilgrim (2021) on their study of middle to high school teachers' adoption of technology at a rural community in the southern part of the United States. Thus, researchers have highlighted the importance of creating a positive school cultural ethos as teachers are more motivated to use digital technology when they feel respected and valued for their work (Apeanti, 2016; Chandra, 2016; Tondeur et al., 2016).

Consequently, at the meso level, the leadership role of the school principal is crucial, as they are the key players influencing the contextual factors that can either expedite or impede the technology agenda (Neira et al., 2018; Porras-Hernández & Salinas-Amescua, 2013). As Chandra (2016) postulated, for technology initiatives to succeed in schools, "principals and school leaders need to become more proactive—they need to be more than just spectators" (p.

244). Chandra (2016) further argues that to exert a positive influence, besides appreciating the potentials of technology, school leaders should have some experience of using technology in their administrative and academic activities. Thus, leaders need to become digitally competent to motivate and encourage their subordinates to adopt technology in their academic practices (Spiteri & Rundgren, 2018b).

Furthermore, Neira et al. (2018) highlight the importance of the principal's role in forming collaborations with other academic institutions. According to Neira et al. (2018), these factors fall within the exosystem level, as these were communications that had to occur among institutions. They believe that addressing the factors at this level can aid teachers to share their experiences and learn from successful practices by forming communities of practice to help promote learning within and outside the institutions (Neira et al., 2018).

The next level, known as the macro context or the macrosystem level, involves the social, political, technological, and economic conditions in which the society operates (Neira et al., 2018; Porras-Hernández & Salinas-Amescua, 2013). Due to the rapid advancements in digital technologies worldwide, national and global policies regarding technology implementation remains especially relevant at this level (Porras-Hernández & Salinas-Amescua, 2013). Thus, strategic planning and policy targets must be developed to collaborate with practitioners to engender extrinsic motivation among school management teams to encourage teachers to embrace technology (Neira et al., 2018). Moreover, to promote the technology agenda at schools, equipping institutions with the necessary infrastructure from the national level becomes imperative. Also, due to the rapid changes in technologies, teachers would require constant learning, and thus, facilitating continuous technology professional development and training is necessary to aid teachers in incorporating digital technologies in their practices (Neira et al., 2018).

The factors presented above show a great diversity of economic, social, political, and psychological dimensions in each of the contextual levels that affect the implementation of ICT in the classroom (Neira et al., 2018). According to Ertmer (1999), internal factors related to teachers are the most difficult to address, as they require a shift in teachers' beliefs, making it more complex to address. Furthermore, since the reviewed studies revealed that the main change agents are the teachers, and the incorporation of digital technology responds to a personal rather than an institutional act (Neira et al., 2018), these factors (teacher-related and non-teacher-related) are explored further in the following sections.

2.2.1. Teacher-related factors

Review of literature reveals a number of factors related to teachers that need to be addressed for effective ICT integration in their classrooms. Amongst these, the most frequently appearing factors were teachers' belief and attitude towards ICT integration, teacher's technology competency and teacher's self-efficacy.

2.2.1.1. Teachers' belief and attitude towards ICT integration

Teachers' beliefs and attitudes towards ICT are essential factors when implementing ICT in teaching (Adam, 2015; Ali, 2015; Barak, 2014; Ekberg & Gao, 2018; Hew & Brush, 2007; Jimoyiannis, 2010; Kinaanath, 2013; Lawrence & Tar, 2018; Neira et al., 2018; Spiteri & Chang Rundgren, 2020). One model that has dominated the research landscape in understanding teachers' attitude towards the adoption of technology is the Technology Acceptance Model (TAM). According to the Technology Acceptance Model, teachers' attitude and behavioural intention to use technology can be influenced by their perception of how useful and easy it is to use technology in their teaching and learning activities (Kinaanath, 2013; Schepers & Wetzels, 2007). Attitude towards technology refers to teachers' general feelings of favourable or unfavourable views on the use of ICT in teaching and learning processes (Lawrence & Tar, 2018). This may include positive or negative perceptions teachers associate with technology which can influence their technology integration (George & Sanders, 2017).

If teachers' attitude towards technology is negative, "providing them with excellent ICT facilities may not influence them to use it in their teaching" (Lawrence & Tar, 2018, p. 93). Often, such teachers have preconceived negative beliefs or lack the confidence to use technology in their classrooms (Jimoyiannis, 2010; Lawrence & Tar, 2018). Barak (2014) uses the term "techno-centric and tokenistic" to explain the beliefs of such teachers. Researchers argue that these negative beliefs can be further manifested if teachers face difficulties maintaining classroom order with certain types of technology (e.g., Tablets), which could encourage students to engage in inappropriate behaviour, thereby disrupting the lesson (Barak, 2014; Spiteri & Chang Rundgren, 2020). Thus, teachers tend to avoid using such technologies if they feel it is an inefficient tool that does not meet their needs or their students' needs, or weakens their authority and brings about distractions in their classroom (Barak, 2014; Lawrence & Tar, 2018).

Although limited, studies within the Maldivian context have also shown that teachers' beliefs and attitudes towards technology does affect their technology integration decisions.

These beliefs are associated with their cultural background, the nature of their teaching subject, and the exam-oriented, content-heavy curriculum (Adam, 2015; Ali, 2015; Kinaanath, 2013). Consequently, teachers have been found to adopt more traditional teacher-centred pedagogical practices such as knowledge transmission, drill and practice activities when adopting digital technologies (Adam, 2015; Ali, 2015; Kinaanath, 2013). This implies that teachers' beliefs, more importantly, their early established pedagogical beliefs, can affect how they adopt digital technologies (Adam, 2015; Ali, 2015; Barak, 2014; Kinaanath, 2013; Spiteri & Chang Rundgren, 2020).

Teachers' attitudes towards the use of technology in classrooms, in turn, influence their students' motivation to learn (Mustafina, 2016). For example, a study was conducted by Prieto-Rodriguez (2016) to investigate mathematics teachers' attitudes towards the use of laptops to teach concepts. The findings revealed that teachers who considered digital technology important used it more regularly to conduct more student-centred activities to enhance students' learning. Researchers proclaim that the constructivist-oriented beliefs of teachers allowed them to adopt digital technologies to engage students in higher-order thinking skills (Barak, 2014; Barak & Dori, 2009; George & Sanders, 2017).

Furthermore, the beliefs and values teachers associate with technology can affect their perseverance to continue using technology, especially under challenging circumstances (Al Harbi, 2014; Ertmer, 1999). Such teachers will continue to adopt technology, provided they perceive it to be beneficial for them and their students, regardless of the many challenges. Thus, teachers' positive attitude towards technology can help them nurture students and motivate them to perform tasks that require a higher level of thinking. Research also shows that other factors influence teachers' attitudes towards technology integration which is explored in the subsequent sections.

2.2.1.2. Technology competency for teaching with ICT

To integrate technologies, teachers need ICT knowledge about not just the tools but how they work in a classroom. This includes the ability to use a wide variety of digital technology devices and their application in their lessons. Many of the past research studies indicate teachers' lack of knowledge and skills on the use of ICT as a key barrier towards effective ICT integration (Bingimlas, 2009; Hew & Brush, 2007; Mukherjee, 2013; Pelgrum, 2001). For example, in a worldwide survey conducted by Pelgrum (2001) comprising 26 countries, they found teachers' lack of knowledge and skills as a key obstacle towards the integration of ICT in primary and secondary schools. Similarly, in a review conducted by Hew and Brush (2007), one of the most prevalent factors was teachers' lack of specific technological knowledge and skills. Likewise, a review conducted by Bingimlas (2009) on barriers to the successful integration of ICT in teaching and learning found teachers' lack of competence to integrate technologies in their instructional practices as a significant hindrance. Thus, if teachers are expected to use technologies in their classrooms, they need the exposure and practice to build their competency and confidence which can be realized by creating opportunities for teachers to "experience and participate in similar learning activities" (Ní Ríordáin et al., 2019, p. 142) that is expected of their students. In fact, helping teachers develop their skills and competence was found to be an important factor in the research conducted by Chalmers et al. (2012) on pre-service teachers' use of robotics in carrying out technology activities with primary school students. They found pre-service teachers' confidence and attitude towards technology use was boosted due to their exposure to robotic based technology activities (Chalmers et al., 2012). All these studies indicate the importance of teachers' knowledge and skills to effectively use technology in teaching their students.

One of the earliest studies discussing the importance of different knowledge and skills teachers require to teach can be found in Shulman's (1987) work. He revealed that teachers require four categories of knowledge base for teaching. These are: Curricular knowledge (knowledge of the materials needed for instruction such as visual materials and media) (Chen & Wei, 2015); Learner knowledge (knowledge of learner characteristics including their subject-related preconceptions) (Angeli & Valanides, 2009; Valanides & Angeli, 2008); Context knowledge (knowledge of educational contexts such as classrooms or schools); and knowledge of educational beliefs (Shulman, 1987). In those early years, digital technology was not a common tool used in education and consequently teachers' technological knowledge was not a key factor in activity design. However, the proliferation of technology in the early 90s brought to the fore new types of knowledge and skills teachers required in order to use technology in facilitating meaningful learning (Ertmer & Ottenbreit-Leftwich, 2010).

Building on Shulman's work (1987), Mishra and Koehler (2006) proposed the technological, pedagogical, and content knowledge (TPACK) framework to help teachers conceptualize the forms of knowledge they require to effectively integrate technology in teaching. According to this framework, teachers need to have knowledge of content, pedagogy, technology, and the complex interaction between and among these three knowledge components. More detail of this model follows later in this chapter (see Section 2.5.1). While having a sound understanding of TPACK is important, research indicates that it is still insufficient for teachers to integrate technology in their classroom successfully unless they are confident about their technology capabilities (Ekberg & Gao, 2018; Lawrence & Tar, 2018). This entails the need to understand how teachers' confidence in their technology ability or self-efficacy towards technology affects their technology integration.

2.2.1.3. Self-efficacy towards teaching with ICT

Technology self-efficacy refers to one’s belief about his/her capabilities to use ICT (Aslan & Zhu, 2017). Research suggests that teachers who are more confident with their technology skills are found to integrate technology in their lessons to a greater extent. Thus, self-efficacy beliefs can influence teachers’ behaviour and choices (Bandura, 1977). Several research reports on the significant influence of self-efficacy on teachers' use of technology in their classroom teaching (Aslan & Zhu, 2017; Ertmer & Ottenbreit-Leftwich, 2010; Hatlevik, 2017; Yerdelen-Damar et al., 2017). For example, teachers with higher levels of self-efficacy are keen to experiment with new ideas and methods using technologies to render students diverse learning experiences and opportunities (DelliCarpini, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Paraskeva et al., 2008; Røkenes & Krumsvik, 2014). Consequently, it is important to create avenues for teachers to build their confidence and self-efficacy to use technology to enhance student learning and engagement (DelliCarpini, 2012; Hatlevik, 2017). This implies that teachers must be afforded the time and training to build their confidence in using technology innovatively to enhance student engagement and learning, in addition to accomplishing administrative and communicative tasks (DelliCarpini, 2012; Ertmer & Ottenbreit-Leftwich, 2010).

According to Ertmer and Ottenbreit-Leftwich (2010), the most powerful strategy to develop teacher self-efficacy is to help them gain personal experiences that are successful (personal mastery). Positive experiences with computers in teaching and learning contexts can help teachers develop a more positive outlook towards technology and increase their confidence in using it in teaching. Furthermore, a teacher’s confidence is seen to be enhanced when they are able to witness students achieving success when using technologies (Ertmer & Ottenbreit-Leftwich, 2010). The literature provides a number of strategies that can be adopted to help teachers develop their technology self-efficacy. These include: ensuring that teachers have sufficient time to play with the technology, working with knowledgeable peers, providing access to suitable models, participating in professional learning communities, and situating professional development programs within the context of teachers' ongoing work while ensuring that teachers have sufficient time to execute the desired changes (DelliCarpini, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Hatlevik, 2017). Moreover, opportunities can be created for in-service teachers during their grade-level or subject-teacher-committee (STC) meetings where they can share their success stories with technology that facilitated student learning. In addition, facilitating opportunities for teachers to observe a colleague who is already using technology in their classrooms is suggested as a useful strategy in building confidence for novice teachers. Considering the influential role of self-efficacy in technology use, and the fact that several research studies report on the significant influence of self-efficacy on teachers' use of technology in their classroom teaching, looking into how self-efficacy plays out in teachers' use of technology in the context of Maldives is deemed necessary for the current study.

2.2.1.4. Teachers' demographic characteristics

Teachers' demographic factors are those that cannot be influenced directly by the school. These include factors such as gender, subject discipline, grade level, and class size, age or teaching experience, and experience with technology (Afshari et al., 2009). There is an extensive amount of literature on the effect of demographic factors on teachers' use of ICT in their teaching (Afshari et al., 2009; Lai & Smith, 2018; Liu et al., 2017; Tondeur, Valcke, et al., 2008).

Studies conducted to identify the effect of gender on technology integration show conflicting results. While some studies found male teachers integrate technology more frequently, others show no significant gender-based differences or females integrating technologies more often. For example, Tondeur, Valcke, et al. (2008) conducted a study to identify the influence of teacher characteristics on adoption of technology in primary education. Their results showed that males used technology more often as opposed to their female colleagues. Conversely, Lai and Smith (2018) investigated how teachers in one New Zealand University used digital technologies in their teaching and learning. They found that female teachers were more open-minded with technology use than their male counterparts. They also found that female teachers had more positive perceptions and willingness to use technology in their teaching (Lai & Smith, 2018). The fact that most of the female participants were young teachers who were involved in teaching in comparison to their male colleagues who were involved with more research work was a possible justification provided by the researchers for this difference.

The research undertaken by Lai and Smith (2018) on university teachers also investigated if subject discipline had any effect on teachers' use of technology. They compared technology use by teachers in humanities and the science faculty. Their findings revealed that humanities teachers' perception towards mobile technology use was more positive than health science or science teachers. Interestingly, this finding contrasted the usual belief that science teachers are more inclined to use technology more frequently (Blum et al., 2007). Thus, more positive perceptions and use of technology held by humanities teachers in contrast to science and health science teachers indicate that teachers' subject discipline was not a significant factor in teachers' technology use. (Lai & Smith, 2018).

Furthermore, literature has shown that the grade level and class size can impact teachers' technology integration efforts. For instance, the seminal work done by Becker (1994) suggests that teachers having smaller class populations tend to make more effective uses of technology. A similar conclusion was made in a study carried out by (Ritzhaupt et al., 2012). They found that grade level and the average number of students per classroom inversely affected the extent to which technology was integrated into a classroom. One justification provided by the researchers for this effect was the comparatively longer time elementary and middle school teachers get to spend with their students daily was a contributing factor for them to use technology more than high school teachers. Another factor was grade level teams and peer support that exist among elementary and middle school teachers. This, they believed created opportunities for professional learning communities and facilitated changes in teaching practices and technology use. In contrast, high school teachers who are often divided by content area and subject culture may not have had the same experience which hindered them from adopting technology (Hew & Brush, 2007). Though these findings are interesting, whether all student groups had similar sizes or access to technology was not clear from their study. The reported student size was a median of 22 students per course, and a median of 11 Internet-connected laptop or desktop computers for each student (Ritzhaupt et al., 2012). This could raise questions about the claims made and thus could be a limitation of the study as the inverse effect could have been a result of unequal access to technology rather than the size or the grade level.

Another factor reported in the literature that affects technology integration is teachers' age and years of teaching experience (Inan & Lowther, 2010; Lai & Smith, 2018; Ritzhaupt et al., 2012). A number of studies depict that the more years teachers had spent teaching, the less likely they were to integrate technology successfully in their classrooms. For example, a survey was done by Holmes et al. (2013) involving 683 Australian teachers found that the years of teaching experience negatively affected teachers' integration of technology. This finding is consistent with prior research which showed that more experienced teachers tended to use computers less frequently (Baek et al., 2008; Russell et al., 2003). Alternatively, there are some studies that show that years of teaching experience did not have an impact on teachers' technology integration (Liu et al., 2017; Perrotta, 2013; Pierce & Ball, 2009). Of interest is a study conducted by Lau and Sim (2008) on secondary school teachers in Malaysia which revealed that older teachers used technology more frequently in the classrooms compared to younger teachers. A similar result was obtained by Russell et al. (2003) who found that new teachers who were more highly skilled with technology than older teachers did not incorporate ICT more frequently in their teaching. These researchers justified their findings based on the years of experience, teachers' maturity levels and their classroom management skills. They believed that it helped experienced teachers manage classrooms more efficiently enabling them to integrate technology into their teaching; provided they had necessary ICT competency. Conversely, researchers believed that fresh teachers who were in their first few years might have experienced challenges getting familiarized with the school's curriculum, tackling classroom management (Lau & Sim, 2008). This could have taken up most of their time causing them to use technology much less compared to experienced colleagues (Lau & Sim, 2008). These mixed findings imply that teachers' years of teaching experience and successful ICT use is complex and not a clear predictor of ICT integration (Buabeng-Andoh, 2012).

One of the strongest factors to affect teachers' integration of technology is their experience with technology (Miranda & Russell, 2012). For example, Miranda and Russell (2012) used secondary data from 1040 teachers from 81 elementary schools. Their study revealed that teachers who were experienced with technology led their students to use technology more often than those with less experience with technology. Another study of 732 teachers from 17 school districts and 107 different schools found teacher experience with technology and also the level of education was significantly related to their use of technology in the classroom (Inan & Lowther, 2010; Liu et al., 2017; Ritzhaupt et al., 2012). This suggests that for teachers to be able to use technology in their practice, they need to gain experience in the use of new technologies (Ní Ríordáin et al., 2019).

Thus, educational institutions need to put a strong focus on scaffolding teacher technology skills in order to support their use of technology for student learning. If these factors are not properly addressed, it may not yield the desired outcome or could even result in negative impacts (Niederhauser & Perkmen, 2008; Pierce & Ball, 2009). Education systems, therefore, need to consider all these internal factors related to teachers when embarking on technology integration initiatives for attaining the desired student learning benefits (Miranda & Russell, 2012).

2.2.2. Non-teacher-related factors

2.2.2.1. School leadership role in successful ICT implementation

The previous section of this review focused mainly on the importance of teacher-related factors for successful ICT implementation. Research has also identified the critical role played by school leadership in the effective implementation of technology plans (Chandra, 2016; Ekberg & Gao, 2018; Phillips, 2015; Rabah, 2015). To foster a culture where teachers want to integrate ICT in their classrooms and see a reason for doing so, school leaders need to provide a vision, set expectations, model the use of technology, address barriers and beliefs, and provide support in terms of resources and professional development (Casamento, 2017; Chandra, 2016).

The school leadership should be able to provide and establish a clear vision and the types of professional development needed to help realize the stated vision (Casamento, 2017). As Chandra (2016) posited, the principal’s ability and vision to innovate and lead the community can “make or break school reform agendas” (p. 242). Research shows that the most effective principals create a school vision for effective technology integration (Machado & Chung, 2015) and articulate clear expectations for its use while creating opportunities for teachers to learn and collaborate (Chandra, 2016; Chandra & Mills, 2015; Dexter, 2011).

Teachers are more likely to integrate technology in their lessons when they are more aware of their principals' expectations (Casamento, 2017). Likewise, a principal's expectation for teachers to use technology have been found to result in a change in teacher beliefs and helped teachers to recognize the potential benefits of using technology in classrooms (Chandra, 2016; Pierce & Ball, 2009). Another key to successful technology integration identified in the literature is the principal's ability to model the use of technology. This requires principals to be familiar with current research and best practices in instructional technology (Afshari et al., 2012) and lead teachers to understand the importance of professional development for technology integration (Casamento, 2017; Chandra, 2016).

When implementing technology in schools, there will always be many unforeseen barriers, and it is the principal's responsibility to address and help teachers overcome these barriers. The most significant barrier is time: time to plan and play with the technologies, time to attend professional development, and time to collaborate (Casamento, 2017; Pritchett et al., 2013). In addition, literature indicates that time can become a barrier to technology adoption if teachers feel that the time allocated to lessons is insufficient (less than 45 minutes), especially when having a heavy workload and a large classroom population size of 35 or more students (Al Alwani, 2005; Al Sulaimani, 2010). Thus, school leaders need to be committed to providing time and training during school hours as teachers need to develop a shared discourse about what technology integration in the curriculum looks like (Groff & Mouza, 2008; Holland, 2001; Jones, 2004; Kirkland & Sutch, 2009; Renfrew Knight et al., 2009; Zhao & Frank, 2003). Additionally, leaders should have the ability to assist teachers to plan lessons that integrate technology, facilitate effective professional development, resources, and create opportunities for teachers to collaborate with colleagues to share best practices. It is also essential to have experts who can attend to technical difficulties faced by teachers (Casamento, 2017; Hur & Oh, 2012). The school culture has also been another barrier that affects teachers' attitudes and beliefs (Casamento, 2017; Hew & Brush, 2007). Thus, the onus is on school leaders to shift the culture within the school environment towards technology integration (Chandra, 2016).

In addition to addressing the barriers, principals are also responsible for changing teachers’ beliefs towards technology integration (Gerard et al., 2010). One way for principals to promote positive beliefs is to demonstrate enthusiasm while supporting teachers who successfully implement technology in their classrooms (Casamento, 2017; Chandra, 2016). One suggested strategy to facilitate removing these barriers is for leaders to pair teachers who have positive beliefs with those who have negative beliefs about technology integration (Casamento, 2017). Additionally, it is crucial to recognize the stages of social influence to understand changes in belief structure. If principals understand the social networks within their institutions, they will be better positioned to deal with issues on teacher beliefs (Casamento, 2017).

Another aspect crucial for successful ICT integration is the availability of necessary resources and support within and outside the school. School leaders must ensure that teachers are provided with the necessary support in terms of resources and professional development at all stages of ICT implementation (Casamento, 2017; Chandra, 2016; Jones & Dexter, 2014; Rabah, 2015). Leaders must also continually evaluate teachers, identify effective instructional technology integration practices, encourage and provide support and additional professional development where necessary (Casamento, 2017). The early adopters or the ICT champions must be nurtured and encouraged to support the other teachers. Likewise, principals should encourage and guide teachers who take risks and are enthusiastic about adopting technology tools to improve learning (Lu & Overbaugh, 2009). As Chandra (2016) professed, teachers presupposing that they have a leader they could rely on for expertise can positively influence them to adopt the technology. Thus, the principal’s ability to role model becomes crucial at this juncture (Chandra, 2016). Where principals lack such expertise, they can provide support by recruiting a technology integration coach to work with teachers both in and outside their classrooms (Casamento, 2017). This kind of collective support can help teachers understand the purposefulness of their work more clearly, which is vital for the success of the technology initiative and student achievement (Chandra, 2016).

In addition to providing the appropriate support to teachers, Rabah (2015) highlights the need for the school leadership team to have a plan and invest in ICT in classroom teaching. This entails the need to develop a plan in which ICT is integrated within the curriculum (Salehi & Salehi, 2012). To facilitate such a plan, Livingstone (2012) recommends the need to redesign the educational infrastructure, curriculum materials, and the modes of assessment at all levels. This whole process of integrating technology in teaching must be effectively managed by the school leadership team by seeking the financial investments from relevant stakeholders (Chandra, 2016; Rabah, 2015). Bringing about such a huge change would require educational leaders to promote a culture of collaboration, provide support for curricular changes and professional development models that would best meet the complex needs of teachers and their contexts (Casamento, 2017; Chandra, 2016; Corey, 2019; Kale & Goh, 2014).

2.2.2.2. The role of teacher professional development training for technology integration

Several studies have demonstrated the importance of professional development (PD) to improve teachers' ICT skills and foster positive attitudes towards technology integration (Alt, 2018; Beauchamp et al., 2015; Chandra, 2019; Corey, 2019; Fenton, 2017; Koh & Chai, 2016). As teachers play a primary role in student learning, the professional development they receive is critical to the success of ICT integration. Researchers also contend that successful PD can aid teachers to develop their self-efficacy and confidence to design, implement and assess lessons using digital technologies (Chandra & Lloyd, 2020; Koh et al., 2016; Lawrence & Tar, 2018). Such PD can also help teachers evaluate student learning outcomes by reflecting on their pedagogical practices (Chandra, 2019; Koh et al., 2016). Thus, the provision of high-quality professional development opportunities can catalyse changes in teacher practice that can result in improved student engagement and achievement (Chandra, 2019; Lawless & Pellegrino, 2007).

Unfortunately, empirical evidence suggests that, though schools conduct technology professional development training, it does not always result in desirable outcomes (Chew et al., 2018; Darling-Hammond & Richardson, 2009; Ekberg & Gao, 2018; Livingstone, 2012; Rabah, 2015). Reasons for this failure include lack of sufficient time and a mismatch between the training conducted and teachers training needs which implies that the knowledge that teachers gain from this training is perceived as irrelevant or inadequate by the trainees (Darling-Hammond & Richardson, 2009; Ekberg & Gao, 2018; Mishra & Koehler, 2006). Research shows that teachers who undergo effective technology professional development have higher technology competencies, are abreast with developments in the field, and also more competent in integrating technology into education (Chandra & Lloyd, 2020; Vanderlinde & van Braak, 2010). Consequently, the purpose of professional development should be to help teachers build well-designed and meaningful lessons with the integration of technology in every classroom.

To establish successful ICT training, it is argued that the training should focus on developing teachers' technological pedagogical content knowledge (TPACK) so that teachers can integrate ICT for meaningful student learning (Chandra, 2020; Chandra & Lloyd, 2020; Koh et al., 2016; Mishra & Koehler, 2006; Owusu et al., 2015b). For this to occur, the training aims and objectives, content, technology, and delivery strategies that make professional development programs effective must first be identified (Cosmah & Saine, 2013; Liao et al., 2017; Mishra & Koehler, 2006). Further, researchers underscore the need to ensure that the training meets the teachers' specific needs and competencies while offering various training options that maintain skill development and are intensive and sustained over time (Darling-Hammond & Richardson, 2009; Vanderlinde & van Braak, 2010). Likewise, giving teachers genuine examples of how to implement the new technology into their day-to-day teaching is vital. To create such avenues, Beauchamp et al. (2015) suggest conducting classroom-based training where teachers get to observe context-specific pedagogical applications of the technology used by more experienced teachers working in similar classroom contexts. This type of training can be more effective as it creates opportunities for more "hands-on" and practical application of the tool they are learning. Thus, if training combines all these elements, it can offer a robust professional development program to support technology integration.

The aim of professional development should thus be to enrich teachers' technology knowledge, attitude, and practices. This level of change would require a transformation in the culture and overall structure within the school (Daly & Conway, 2015). Thus, professional development training should incorporate mentoring, coaching, direct instruction, and the sharing of best practices (Chandra, 2020). According to Beauchamp et al. (2015), sufficient time to practice and experience the knowledge acquired from professional development sessions are a critical requirement. When teachers receive the PD support they need to implement technology; they will more likely embrace the new tools, resulting in the successful implementation of ICT (Chandra, 2020).

Additionally, research has also shown the benefits of self-directed learning and how it has been instrumental for teacher professional development, since the desire to learn stems from intrinsic motivation, the learning becomes more relevant to teachers' specific needs, resulting in more meaningful learning (Beauchamp et al., 2015). Further, teachers forming their own personal learning network (PLN) or personal learning communities (PLC) has been beneficial for teacher professional growth as they can share good practice, ask questions of others within the group and arrange classroom swaps where teachers visit each other's schools in turn (Beauchamp et al., 2015). Darling-Hammond and Richardson (2009) believe that this will allow teachers to reflect on new practices in their specific context and share their knowledge and expertise through two very effective PLC strategies: 'Peer observations of practice' and 'Study group'. 'Peer observations of practice' is where teachers visit each other's classrooms to provide feedback and assistance. It can be done by video recording their own lessons and self-critiquing or getting colleagues to critically appraise their teaching (Beauchamp et al., 2015; Hord, 1997) to help improve teaching practices, and technology integration effectiveness (Lustick & Sykes, 2006; Sato et al., 2008; Sherin, 2004). 'Study group' is where teachers work collaboratively to research and practice strategies and concepts in implementing new ideas, and has been reported to help improve teachers' practices, raise expectations for traditionally underperforming groups, and create relevant and engaging curriculum (Darling-Hammond & Richardson, 2009; Phillips, 2003).

Lastly, professional development for technology integration should provide mentoring and just-in-time assistance for teachers as they embark on their technology journeys. For such opportunities, Gupta (2016) suggests collaborating with sources within and outside the school to identify and direct teachers for training opportunities. Empirical evidence indicates that if adequate professional development is not provided, the selected technology becomes just another tool. Hence, as technology continues to become more widespread within school systems, its success will depend on the quality and depth of teacher preparation achieved through well-planned professional development (Bebell & Kay, 2010; Chandra, 2020; Chandra & Lloyd, 2020).

2.2.2.3. Importance of ICT resources and access to the available resources

Access to technological resources is one of the basic prerequisites for teaching and learning with technology (Lawrence & Tar, 2018). Previous research shows that a lack of access to technological tools and resources is a significant barrier towards the use and integration of ICT (Drossel et al., 2017; Francom, 2016; Lawrence & Tar, 2018; Makhlouf & Bensafi, 2021). For instance, a study by Makhlouf and Bensafi (2021) to identify the factors affecting Algerian secondary school EFL teachers' integration of digital technologies found access to technological resources, amongst other factors, impacted teachers' use of technology in teaching. This is supported by Lawrence and Tar’s (2018) study which also found that access to ICT infrastructure and resources in schools is a necessary condition for the integration of ICT in education. The adoption and integration of ICT depend mainly on the availability and accessibility of ICT resources (Lawrence & Tar, 2018). A lack of access to resources is most often due to financial restrictions. Thus, institutions with adequate financial and technological resources are better equipped to undertake complex innovations using ICT (Lawrence & Tar, 2018). In such contexts, teachers have more avenues to adopt ICT in classroom teaching and are likely to experience higher teaching and learning benefits in using technology. Thus, availability and accessibility of resources (e.g., computers, software, and hardware) are critical to the adoption and integration of ICT (Makhlouf & Bensafi, 2021). This finding is consistent with past research that found organizational resources to be influential in the adoption of ICT (Drossel et al., 2017; Kale & Goh, 2014; Wright & Wilson, 2011).

In addition to having resources, it is equally important that the schools provide the necessary technical support in terms of software, hardware and skill building when integrating ICT (Lawrence & Tar, 2018). Korte and Hüsing (2006) argue that having technical support readily available impacts teachers’ ability to apply technology in classrooms without worrying about wasting time troubleshooting hardware and software problems. Contrarily, the lack of technical support inhibits teachers from integrating technology in classrooms (Korte & Hüsing, 2006). As teachers are not technical experts, they need to be given assurance that they will have the necessary technical assistance when things go wrong. In fact, one of the reasons why technology initiatives fail even when the necessary software and hardware are provided is due to inadequate technical support available to teachers. Often this is because teachers are not sure where to seek assistance if something goes wrong while using computers. Thus, having technical support readily available could motivate teachers to utilize technology in their classroom activities (Korte & Hüsing, 2006). Similarly, Yilmaz (2011) reported that in addition to facilitating schools with hardware and internet connections, it is also essential that schools are provided with necessary technical support staff to maintain the resources in optimal condition. Where the school is unable to provide technical support, teachers become frustrated, resulting in a lack of motivation to use and integrate technology into their teaching activities (Lawrence & Tar, 2018).

These resource related barriers are more inherent in resource constrained SIDS countries such as the Maldives. Thus, providing teachers with the technology, equipment, and support and also establishing mechanisms to share the limited resources to ensure maximum accessibility for all users is extremely important for successful technology integration (Al Harbi, 2014).

2.2.2.4. ICT policies and planning for successful ICT integration

Another key factor influencing the success of technology implementation initiatives in schools is the lack of appropriate ICT policies and related strategies (Al Harbi, 2014). Thus, to ensure the successful integration of ICT, an effective ICT policy is required (Wachira & Keengwe, 2010). However, this is one of the least discussed areas when reporting on the factors impacting ICT integration in schools (Han et al., 2018). However, recently, researchers, as well as policymakers, have begun focusing more attention on this important factor when planning to integrate ICT in schools. Thus, the importance of developing a school-based ICT policy plan is deemed as a key step towards integrating ICT in education (Tondeur, van Keer, et al., 2008). Research shows that having sound ICT policy and plans can help schools utilize technology effectively for teaching, learning, and other administrative purposes. For instance, Tondeur, van Keer, et al. (2008) found that in schools that had an explicit ICT policy plan, educational technologies were used more regularly in their classrooms. Similarly, ICT policies that enhance teacher technology professional development and provide resources were found to stimulate technology implementation in Hong Kong (Han et al., 2018; Wong & Li, 2011).

According to Vanderlinde et al. (2012), ICT policy planning is the underlying process that leads to the school-based ICT policy plan and involves developing, revising, and implementing ICT plans that guide the organization towards the broader technology implementation goals. The plan, therefore, includes a vision for using ICT in classrooms, technical infrastructure specifications, the learning objectives for ICT use, including implementation strategies, an outline of professional development requirements, ICT skills expectation of teachers and students, ICT curriculum, hardware, software, and funding requirements (Vanderlinde et al., 2012).

Researchers argue that ICT policy is an important incentive to foster the integration of ICT use in the classroom, but only if teachers are aware of its content (Han et al., 2018). Therefore, getting teachers involved in the process of ICT policy planning can be useful. According to Tondeur, van Keer, et al. (2008), involving teachers in the policy development process allows them to reflect on their pedagogical practices and helps them determine the subjective meaning of how and why they would integrate technology in their classrooms). Furthermore, Tondeur, van Keer, et al. (2008) believe that it is more likely for ICT initiatives to succeed when teachers understand the policy implications and can share and express values towards achieving the policy targets (Tondeur, van Keer, et al., 2008). In this way, teachers feel included in all stages of the process. In addition, they should also include teachers in the planning and development process (Chandra & Mills, 2015), and high-quality professional development should stay at the centre of an ICT policy (Zyad, 2016). The policy planning process should be guided by someone like the school leader (Hayes, 2007) or the ICT coordinator (Devolder et al., 2010) or an ICT champion (Chandra et al., 2014). Accordingly, policymakers and leaders need to allocate sufficient funding to equip schools with necessary hardware (e.g., computers, projectors, internet connection) and software (educational programs and learning management systems) (Zyad, 2016). Besides, effort should also be made to consider how ICT can be seamlessly integrated within the curriculum so that teachers do not see it as an extra add-on element (Zyad, 2016).

Furthermore, because an ICT policy plan is a dynamic document, it is subject to continuous improvement and revision (Vanderlinde et al., 2012). Consequently, its implementation should be monitored and frequently (Vanderlinde et al., 2012). The policy document will also need regular formative evaluations to ensure that the aims and objectives in the intended plan are being achieved (Han et al., 2018). Moreover, policymakers should disseminate ICT policy plans and provide training sessions for school leaders and ICT coordinators on how to establish school-based ICT policy plans (Vanderlinde et al., 2012). Thus, ICT leadership is an essential prerequisite for ICT policy planning (Tondeur et al., 2009).

Moreover, as Mukhari (2016) claimed, education authorities (e.g., the Ministry of Education) play a substantial role in establishing ICT in education policies in schools. They render the necessary infrastructure and ICT facilities for schools, facilitate teacher professional development training to boost their confidence and competence to adopt digital technologies. Furthermore, being leaders, school principals are tasked with developing school-level ICT policy plans to implement technology in schools. However, literature shows that unclear policy directives from educational authorities pose challenges at the implementation stage (in schools) (Mukhari, 2016). This signifies the need for systematic and explicit ICT policy strategies at a national level (e.g., providing ICT facilities and resources, building teacher confidence and competence to use technology through effective professional development programs). Further, these policy directives should consider other external stakeholders (e.g., private organizations, NGOs, parent-teacher associations, and students associations) to collaborate in carrying the ICT in the education agenda forward (Mukhari, 2016).

Akin to the literature discussed above, in the Maldives, often, when technology is introduced into schools, proper planning and related policy changes are not addressed until much later (see Section 2.4.4). Thus, it is important to ensure that there are clear policies and planning strategies that articulate the vision, goals, and objectives of technology initiatives. It is also imperative that these policies, vision, goals, and objectives are clearly communicated to stakeholders to make technology implementation initiatives successful.

2.2.2.5. Culture and ICT integration

Introduction of ICT into the classroom can destabilize the normal routine of classroom teaching; particularly in terms of time and space (Somekh, 2008). Thus, the acceptance of a new technology depends on how well the proposed innovation fits within the existing school culture (Afshari et al., 2009). For technology innovation to be readily accepted, it should avoid too much deviation from teachers' existing values, beliefs, and practices (Zhao & Frank, 2003). Although possessing the relevant knowledge, confidence and beliefs seem to be sufficient to empower teachers to integrate technology into their classrooms in meaningful ways, this approach does not work for the vast majority of teachers (Ertmer & Ottenbreit-Leftwich, 2010). Teachers are bounded by the cultural, social, and organizational contexts in which they live and work (Somekh, 2008). If the overall school culture is encouraging, this can have a positive effect on teachers' attitude towards technology use and vice versa. In such an environment, confirming to the general norm is important; especially to teachers, given the particularly strong cultures that exist within schools (Roehrig et al., 2007; Somekh, 2008). Thus, the school culture, especially with regard to ICT-related teacher cooperation, is an important predictor of teachers' technology use (Drossel et al., 2017; Law & Chow, 2008; Shameem, 2016).

Leidner and Kayworth (2006) describe culture as a “system of beliefs about behaviour, relationships, reality, and truth that operate as interpretive schemes that people use to perceive situations and give meaning to experiences” (p. 354). This includes essential values people find in objects and creations, such as artwork, technology, myths, rituals, and the like (Leidner & Kayworth, 2006). School culture is the shared experiences that create a sense of community, family, and team membership (Wagner, 2006). Over time, this shared beliefs and experiences often become the underlying assumptions that permeate the way they do things at school (Bate, 2010; Hammond & Shameem, 2012). Hence, school culture can affect teachers' attitudes toward technology integration (Apeanti, 2016).

A meta-analysis conducted by Schepers and Wetzels (2007) to study the relationship between technology acceptance across different countries and their attitudes toward technology use found significant differences in acceptance of technology based on cultural characteristics of nations. As teachers’ attitudes towards technology are linked to their school culture, researchers advocate a socio-cultural approach to foster a more positive outlook towards technology in schools (Somekh, 2008). Furthermore, according to Voyiatzaki and Avouris (2014), a positive learning culture entails enhanced collaboration and adaption of learning environments tailored to student needs. Thus, researchers suggest learning communities as a possible solution for teachers to share their knowledge and opinions and discuss new methods and strategies to support each other (Ertmer, 2005; Hammond & Shameem, 2012).

Furthermore, as discussed above, to foster a supportive school culture that promotes teachers’ technology integration, it is crucial to have support and encouragement from competent leaders (Spiteri & Rundgren, 2018a; Tezci, 2011). Similarly, a school culture that promotes dialogue, shared values, and risk-taking are important facilitators of ICT implementation in schools. In an environment which facilitates sharing of teaching practices, teachers can encourage one another to integrate technology into classrooms. This can open avenues for teachers to communicate with colleagues and share best practices which can be beneficial as teachers learn about time-saving and improved lesson preparation and how to use technology more effectively (Al Mofarreh, 2016).

In summary, this section of the literature has reviewed the benefits that support the use of technology in teaching and learning and the factors that can affect teachers’ integration of technology in their classroom practices. A summary of the key literature on factors influencing teachers’ technology integration in different contexts can be found in Appendix A. Consequently, it is crucial to consider these challenges holistically to enable teachers to navigate the potential barriers in their technology integration efforts. However, the factors explored in this section hitherto, were within the broader, global context. Since the current study is situated in the Maldives, a small island nation that has no published research on the area being explored, understanding the status of ICT integration by teachers and the factors that affect their technology integration in SIDS similar to the Maldives becomes important to understand the context for the present study. Therefore, the next sections articulate the status of ICT in education in small island developing states similar to the Maldives followed by the status if ICT in education in the Maldives.

2.3 STATUS OF ICT IN EDUCATION IN SMALL ISLAND DEVELOPING STATES (SIDS)

Technology has offered numerous opportunities for progress in all aspects of life, both in developed as well as developing nations (Hinostroza et al., 2014). As a result, there has been a rapid increase in the integration of ICT in various sectors over the past decade. The benefits of ICT can be significant, especially for small island developing states (SIDS) such as the Maldives, as it has the capacity to bring the major centres of production and consumption together through its isolated and widely dispersed networks. According to UN-OHRLLS (2011), Small Island Developing States (SIDS) are a distinct group of 52 developing countries recognized as a special case due to similar kinds of social, environmental, and developmental vulnerabilities they are exposed to. The ICT infrastructure in most developing states is limited, but the belief that ICT can positively impact society through its use in education has resulted in many countries investing in technology-focused ventures. The evidence of consequential progress from these undertakings varies from project to project and country to country. Henceforth, this section will explore the status of ICT in the secondary, higher secondary as well as tertiary education curriculum in some of the countries that fall within the SIDS basket, including Mauritius, Fiji, Papua New Guinea, and Tonga.

In Mauritius, all primary and secondary schools are equipped with Desktop Computers in their Computer Labs (Republic of Mauritius, 2018). The government also distributed 26800 tablets to all the primary students and provided access to educational resources via a web portal from multiple platforms to secondary students (Republic of Mauritius, 2018). In addition, many state secondary and private schools have SMS E-Register systems, Smart / interactive whiteboards with access to internet facilities for students' use in the school library (Ministry of Education and Human Resources, 2014). In tertiary institutions, e-Learning was introduced to provide greater access and capture a wide range of lifelong learners. Further, Mauritius witnessed an increased proliferation of ICT in recent years, and it has been acknowledged as a vital tool in bridging the digital gap across the nation.

Similar initiatives have been taken in some other developing countries. For example, in 2013, the Ministry of Education in Fiji implemented the One Laptop per Child (OLPC) program in selected schools (Nath, 2018). As a consequence, computer science was offered as an optional subject in these schools. Recently, in 2018, the Ministry of Education made the computer education curriculum mandatory for Year 7 and 8 students Nath (2018). The aim was to enhance students' computer literacy and prepare them for the fast-changing information society. As part of this program, all three universities in Fiji taught IT courses (Mow et al., 2017).

ICT use in education in Papua New Guinea is low compared with many of its neighbours, mainly due to the limited teaching facilities and resources (Moresby, 2018). Though ICT is not in its primary curriculum, since 2008, Papua New Guinea has incorporated computer studies for the two senior years as part of the high school curriculum with a focus on information literacy, computer-based communication, and computer technology solutions (Papua New Guinea Department of Education, 2016). Moreover, in the National Education Plan (2015-2019), strategies were included to set up ICT facilities in school libraries and implement a fully integrated digital information system and an electronic school register as part of its education management information system (EMIS) (Papua New Guinea Department of Education, 2016).

Meanwhile, in Tonga, computer science is included in the curriculum in secondary schools as well as at the tertiary level (Mow et al., 2017). In addition, the University of South Pacific (USP) and the Tonga Institute of Higher Education (TIHE) offer computer science programs as tertiary programs, while Church schools and some private companies offer diploma-level courses. In addition, to build up business skills in the country, the Tonga Chamber of Commerce offers training programs on office applications coordinated through the Tonga Business Enterprise Centre and with assistance from the New Zealand government (Mow et al., 2017).

Other ICT initiatives in these developing states include the One Laptop per Child (OLPC) project, piloted in eight Pacific Island countries including Samoa, Fiji, Vanuatu, and the Solomon Islands from 2008 to 2010 (Mow et al., 2017). Likewise, Vanuatu has started to manage its own more sustainable e-learning opportunities (Mow et al., 2017). As part of its Universal Access Policy, Vanuatu successfully launched 22 community telecentre sites, of which 15 are located in schools that have access to ICT and internet services. This service was extended to local villagers to attend classes after-school hours (Minges & Stork, 2015). Likewise, in Tuvalu, each school is equipped with a digital projector for in-house professional development as well as class activities such as student presentations (Mow et al., 2017). Fiji has also launched several projects that provide computers and internet access to schools. One such initiative is the Share, Engage and Educate (SEE) project run by volunteers (Chandra, 2020; Chandra & Chandra, 2013). Through this initiative, Fiji provided over 200 computers and robotic kits, digital cameras, and data projectors to schools (Minges & Stork, 2015). More recently, this number has crossed the 1000 mark (Chandra, 2020). The Queensland University of Technology, Australia, and individual parties donated equipment for the project (Chandra, 2020). The Fiji Department of Communications established a telecentre program providing after-school computer access for the community. Fiji also benefited from an OLPC initiative in late 2015. Under this project, 1500 laptops were distributed to primary schools, and 5000 tablets were delivered to rural and remote schools (Mow et al., 2017).

In sum, despite small-scale initiatives, research suggests that using ICT for improving teaching and learning is still a work in progress in SIDS due to several challenges (Chandra, 2020; Kinaanath, 2013; Mow et al., 2017). These include lack of proper infrastructure, high cost of hardware, lack of capacity to maintain ICT in schools, lack of knowledge and skills, lack of funding to train the human resources required to sustain such initiatives, lack of ICT-guided policies, and lack of trained teachers, which are homogeneous across most SIDS (UNESCO, 2015). Therefore, these challenges suggest the need to understand the issues further to facilitate effective technology integration in these contexts.

2.3.1. ICT in education in teacher training in SIDS

Preparing teachers to effectively adopt ICTs in teaching and learning has been reported in several research investigations within the context of wealthy nations (Fraile et al., 2018; Instefjord & Munthe, 2017; Tondeur et al., 2017; Williams, 2017). However, technology training in resource-constrained developing countries; with unique local complexities and challenges is limited (Mow et al., 2017). As a consequence, the way ICT training is conducted in developing countries remains largely unknown; especially considering how the training impacts on teachers' ICT use.

Most SIDS acknowledge the need to support teacher training in ICT for its successful integration in education (Lingam et al., 2015). Thus, ICT training is included within the teacher training programs in most of the developing states. For instance, in Samoa, all pre-service teacher education students are required to take an introductory course in computer basics and computer applications. This includes minors and majors in computing, in diploma and bachelor of education programs for those intending to teach computer studies in secondary schools (Mow, 2010). In addition, students preparing for secondary teaching are required to complete courses focused on pedagogies in computing. Similarly, it is mandatory for students enrolled in the primary pre-service teacher education program to take a new computer literacy course (Mow, 2010).

The rapidly changing nature of technologies also mandates ongoing training. In all SIDS, in-service teachers are in dire need of training. Haphazard training is sometimes provided in the form of continuous professional development (Chandra, 2020). In a few instances this training has morphed into other forms. For example, in Fiji, a ‘Teacher Resource and eLearning Centre' was established in mid-2012 to facilitate online training for teachers (Lingam et al., 2015). This facility was designed to deliver pathways for the continuous professional development for teachers across the region. The ‘Teacher Resource and eLearning Centre’ conducts workshops for in-service teachers to help them prepare to teach with ICT. Since teachers are the designers of the teaching-learning processes, being ICT literate implies having the capability to integrate digital technologies in the teaching and learning process (Fraile et al., 2018). Yet, in some SIDS, teacher training is not necessarily provided by a university and ICT courses are not included in the teacher training (Mow et al., 2017). For example, in the Solomon Islands, high frequency radio is used to broadcast education and educational programs to teachers in remote locations (Mow et al., 2017). Likewise, in Papua New Guinea colleges, teachers are taught basic IT skills, but are unable to access materials, or teach the subject due to lack of internet services (UNESCO, 2015). Therefore, much work remains to be done to train teachers, especially those already in the service but are reluctant to learn new skills and methods in SIDS (Mow et al., 2017).

2.3.2. Challenges faced by SIDS in implementing ICT in education

The unique context of small states exposes them to a number of challenges. Some common challenges include low population, lack of human capital and low economies of scale, limited resources, restricted opportunities for diversification and economic activities, remoteness and/or isolation, susceptibility to natural disasters, and fragile environments (Atchoaréna et al., 2008; Crossley & Sprague, 2014; Longenecker & Barnum, 2017; Waheed, 2013). Lack of human capital and the lack of economies of scale results in limited institutional capacity. Small economies mean SIDS are more exposed to outside influences, socioeconomic and cultural vulnerability as they tend to have a high level of external dependency and emigration. Small states also experience more income volatility and poverty, plus the high external dependency and economic vulnerability lend themselves to considerably uncertain income levels (Mow et al., 2017).

The small population size also has implications for other development indicators. For instance, governance, provision of equitable communication and transportation becomes challenging for SIDS due to the small population which is unevenly scattered across the different islands. Furthermore, the flow of migration from remote locations to urban areas results in overpopulation of these areas (Kinaanath, 2013). For example, in Fiji, 87% of the nation's population lives on the two main islands, while the remaining 13% is distributed across the 108 small islands (World Population Review, 2021). The situation is similar in the Maldives where one-third of the country's population is concentrated into two main islands. When the population is mainly constrained within a limited land area, this can cause huge constraints on its scarce resources. Moreover, the limited population in SIDS implies that they cannot benefit very much from economies of scale (Kinaanath, 2013).

Thus, in terms of the population size, land area and Gross Domestic Product (GDP), the SIDS nations face several difficulties in implementing sound education systems embracing effective technologies. Proper infrastructure is crucial in schools to enable teaching and learning using ICT. However, most SIDS face challenges due to lack of proper ICT infrastructure and the high cost of internet and telecommunication services (Kozma & Vota, 2014; Mow et al., 2017). Furthermore, communication infrastructure is not equally developed in all the islands. Generally, capital islands enjoy better communication facilities and universal access to telephones, radio, television, and the Internet, while remote islands have limited access (Mow et al., 2017). In addition, SIDS are challenged due to the limited finance for curriculum development, high teacher turnover, lack of ICT teachers and experts; lack of a planned ICT curriculum; lack of resources and access to technology, limited support and opportunity for development (Mow et al., 2017; Salas-Pilco & Law, 2018), and lack of appropriate ICT policies and ICT trained teachers (Ali, 2015; Kozma & Vota, 2014; Mow et al., 2017). Similar challenges have been reported in studies conducted in more affluent countries (e.g., Chandra and Mills (2015). Therefore, there is a grave need to understand these challenges so they can be addressed to appreciate the benefits from ICT integration projects.

This section looked into the status of ICT in education in the context of small island developing states (SIDS). It specifically examined the literature on ICT in education in teacher training in the context of SIDS (Section 2.3.1) and the challenges faced by SIDS in implementing ICT in teaching and learning (Section 2.3.2). The challenges common to most SIDS include lack of appropriate resources and infrastructure, high cost of hardware, geographic disparities due to remoteness, lack of capacity to maintain ICT in schools, lack of ICT experts and teachers, lack of funding to train the human resources required to sustain such initiatives, lack of ICT-guided policies and lack of trained teachers (Mow et al., 2017). Since the Maldives is also a SIDS, and as there are no published work on the status of ICT in the Maldives, the SIDS context explored in this section sheds some light on ICT integration and challenges faced by these countries which might present similarities in the Maldivian context too. The next section explores the context for the current study in detail.

2.4 TECHNOLOGY INTEGRATION IN THE MALDIVIAN CONTEXT

The Maldives is an island nation in the Indian Ocean–Arabian sea area, comprising a double chain of twenty-six atolls and more than 1,192 islands that stretch 823km from north to south and 3130 km from east to west (Maldives, n.d). Situated between Minicoy Island and the Chagos Archipelago, the country has approximately 400,000 inhabitants: 310,000 Maldivians and 90,000 expatriate workers (Ministry of Education & Ministry of Higher Education, 2019). Roughly 33% of the populace (153,379) dwells in the capital, Male', an island of around two square kilometres, while the rest are distributed among just under 200 other inhabited islands (Ministry of Education & Ministry of Higher Education, 2019). Conversely, in 72 inhabited islands, the population is below 1000. The Maldives thus fits the small island developing state category with characteristics such as remoteness; small size and limited natural and human resources; reliance on foreign aid; and susceptibility to climate changes and natural disasters (UNDP, 2014). The human development index (HDI) of the Maldives as of 2019 was 0.740, a remarkable figure compared to other South Asian countries (UNDP, 2020), and the gross domestic product (GDP) stood at 4.03 billion US dollars by the end of 2020 (Trading Economics, 2021). The main contribution to GDP comes from the Tourism sector (one-quarter of the GDP), followed by the Construction and Real Estate sector and Fisheries, Transportation, and Telecommunications.

The spread of tiny islands across a wide geographic area and the unequal distribution of population across the 200 inhabited islands poses several challenges for the Maldives when it comes to the provision of equitable services and developmental initiatives. For instance, the provision of quality health and education services that is fair to the entire population has been an ongoing challenge. Despite these barriers, the government has taken proactive steps to ensure that each child is given access to free health and education. As a result, almost all the islands have a primary school that caters for children in grades 1-7 in the small islands. On the larger islands with higher population densities, secondary and higher secondary schools enrol students in grades 1- 12 (Di Biase, 2018). According to the education sector analysis report, student enrolment at lower secondary education level has been very high (90.5% in 2018) (Ministry of Education, 2019). The country follows a local curriculum from grades 1 to 8, and an international curriculum (British system of O-level and A-level examinations) for the secondary and higher secondary levels (Di Biase, 2018).

The Maldives has achieved a high literacy rate of 98% (Ministry of Education, 2019). However, providing high-quality education has been a challenge. Also, due to its dependence on the external examination system (GCSE O-level and A-level), teaching is very result-oriented, and grades are emphasized over learning. Thus, many students lack appropriate communication, time-management, and leadership skills when they leave school (Shiuna & Sodiq, 2013). Moreover, the pedagogical approaches adopted by most teachers evidence that they give more preference to rote learning compared to constructivist-oriented teaching practices. Adam (2015) contends that this trend is related to teachers' early established pedagogical practices of teacher-centred rote learning and the social-cultural practice of learning to memorize the Quran. This has implications when students graduate and seek work. According to a report produced by UNDP, the graduates who complete their education programs cannot meet the demand for a skilled workforce (UNDP, 2014). Consequently, to address these limitations, a new national curriculum framework (NCF) was introduced into the Maldivian schooling systems in 2014 (NIE, 2014). The NCF was outcomes-based, and it aimed to promote a holistic approach to education using a learner-centred approach (NIE, 2014).

2.4.1. ICT in education in the Maldives

Integration of technology in Maldivians schools began in the late 1990s with the introduction of the whiteboard in classrooms, laboratories, media rooms, and computer classrooms. By 2008, Smart board technology and Internet-based smart libraries were slowly being set up. With generous donations from parents, community members, and international donors, many schools started investing in a technology acquisition program. They purchased technologies such as data projectors, Smart TVs, Smart boards, laptops for teachers, and tablets for students (Ministry of Education, 2019). Most of these were small-scale projects initiated by school leaders to gain competitive advantage from the affordances of these technologies.

During this same period, the Maldivian government was also seeking opportunities to enhance education through ICT integration. Consequently, they began collaboration with national and international partners. This opened numerous developmental opportunities throughout the country, including smaller, more remote island communities. The government has implemented several programs to enhance education through ICT. For example, the establishment of 23 Teacher Resource Centres (TRCs) across the Maldives, a collaboration between MoE, Dhiraagu (National Telecom Service Provider), and UNICEF created new educational opportunities; especially for schools located in the remote islands (Ministry of Education, 2019). The TRCs are equipped with modern technology such as Smart boards and microwave relays, and cable Internet technologies. TRCs enable teachers to browse the Internet to download and develop materials for their lessons. Nevertheless, access to locally produced materials and resources is limited. Perhaps, one of the main strengths of TRCs is their capacity to carry out teacher training for large groups (400 teachers interact with one another at a given time) remotely via the virtual learning environment (UNESCO, 2010). Ever since their establishment, TRCs have been conducting various upskilling and professional development training for schools (Ministry of Education, 2019).

A more recent, and perhaps the largest project MOE has embarked on so far is the 'Digital school' project. With the implementation of this project, the government provided students and teachers in all the public schools with a Tablet PC throughout the country (Ministry of Education, 2017). According to the draft report on the ICTMP 2021-2024, Tablets have been distributed to all students from grade 3 upwards in government schools (Ministry of Education, 2021). As per MoE guidelines, schools arranged for students to take tablets home and practice. However, the lack of adequate internet access at home has been reported as an issue; especially for students from socially disadvantaged backgrounds (Ministry of Education, 2021). The aim of this initiative was to "provide students with opportunities to be engaged in a technology-enhanced environment that enhances teaching, fosters learning and develops 21st-century essential life skills for all students" (Ministry of Education, 2017, p. 2). For such an initiative to succeed, the skills and qualifications of teachers at the ground level is significant. Consequently, teachers need to be skilful to adopt these technologies to transform their practices. In preparation for the launching of this project, the MoE conducted professional development training to equip teachers with the required skill and knowledge, but not without challenges. Under this initiatives MoE also introduced an educational repository called ‘Filaa’, to make digital content available for teachers and students (Ministry of Education, 2021).

Another important and more recent milestone in the Maldivian education sector was the ratification of the first Education Act, which necessitates the provision of free and compulsory education from K-10 (The Presidents Office, 2020). In addition, it is noteworthy to mention Article 7 of the Act, specifies that students should be exposed to technology and be taught to use the internet safely. Thus, this requires the MoE to plan for the equitable provision of modern technology and technical and vocational skill development in schools (Ministry of Education, 2021).

2.4.2. Technology integration challenges in the Maldives

Similar to other SIDS, the Maldives faces several challenges with implementing technology in education. For instance, Maldivian schools face several infrastructure-related issues related to hardware (multimedia hardware and broadcast media such as radio and television), software, and content development. In addition, there are network-related issues such as broadband Internet and a lack of sufficient technological support. Some schools have computers with projectors or Smart boards / Smart TVs in the classroom, while others are equipped with just a computer system or a computer lab for the use of students and teachers (Ministry of Education, 2019). Most schools use the Internet for administration and communication purposes, and the connection speed for the majority (70%) of the schools is between 4 to 8 Mbps (Ministry of Education, 2019). The high cost and the low speed do not allow many schools to provide Internet or Wi-Fi access for teachers and students to incorporate the available technology tools directly inside the classroom for learning activities (Ministry of Education, 2019).

The challenges faced due to the system and related sector policy changes can lead to project failures if not appropriately addressed (Shibana, 2016). One of the crucial factors of successful technology implementation initiatives is clear and stable policies as changes in national-level policies can result in a series of changes in the follow-up policies, programs, and resources that connect the initial target components within the system (Shibana, 2017). A good example is the NCF introduced in 2014, where much emphasis was given to holistic education and digital technologies in teaching (NIE, 2014). This required teachers to learn new pedagogical approaches to adopt technology to achieve curriculum targets and related assessment strategies. However, as evidenced from the Education Sector Analysis report, the teachers have not been able to meet the NCF requirements mainly due to a lack of cohesion between the sectors in ensuring the resources and training necessary to prepare teachers and administrators to make the implementation successful (Ministry of Education, 2019). Thus, solid and stable policies should be developed and articulated well to address the training needs of teachers that allow teachers to adopt digital technologies to promote holistic, meaningful learning and assessment strategies. Thus, the Maldives requires broader contextual changes to articulate a shared vision and motivate people to adapt and coordinate effectively.

Further, research shows that teachers' pedagogical practices are closely related to their academic level and their training. The lack of adequate technology training has been reported to pose several challenges for the government in providing equitable education to all children across the country (Ministry of Education, 2019). Evidence from official reports suggests that a large percentage of current in-service teachers, (especially in the local subjects Dhivehi language and Islam, and primary year levels) graduated with certificate level qualifications more than a decade ago (Ministry of Education, 2019). Thus, teacher professional development should be reflected in education policies. However, there are challenges in providing training due to a lack of expertise in the field (Ministry of Education, 2019).

Moreover, teachers need time to familiarize themselves with the new curriculum requirement that comes with technologies. In such situations, teachers are released to attend professional development sessions. However, these PD sessions are often ineffective as it does not directly connect the content with the curriculum being taught (Blundell, 2017; Mohan et al., 2017). Thus, releasing teachers from their daily teaching routines to attend these training sessions has been counterproductive as teachers miss their classroom teaching hours and do not gain much from the sessions. Often these PDs follow the traditional ‘one size fits all' approach where each PD session is conducted on different, unrelated topics and carried out for a short period, which does not meet the teachers' needs (Mohan et al., 2017). Moreover, the absence of ICT policies and standards and the paucity of appropriate technology professional development and training guidelines pose further challenges that must be addressed to make the technology implementation initiatives successful.

2.4.3. Teacher training in ICT in the Maldives

With the widespread use of digital technologies within the education sector, teacher training has become exceedingly important. However, research has shown that due to various factors and the contextual situation, teacher training for technology integration has been a challenge both in developed as well as in developing countries. Subsequently, as this study’s context is situated in the Maldives, it faces challenges similar to other SIDS when it comes to training teachers to integrate ICT in their teaching and learning.

In the Maldives, there are a number of universities and colleges that are accredited to conduct teacher training. This includes two public universities, the Maldives National University (MNU) and the Islamic University of Maldives (IUM) and four private colleges that provide teacher education programs. The MNU is the main body where most pre-service teacher training happens. In addition to the MNU, recently the IUM was founded and offers some teacher training programs. The MNU prepares teachers in its Faculty of Education (FoE), Faculty of Islamic Studies (FIS) and Centre for Open Learning (COL). Both the FoE and the FIS offer their teacher training programs face to face; the COL offers teacher training courses in distance mode throughout the country (Rasheed, 2017). In addition to the two universities, Private colleges also offer teacher training. These include Villa College (VC), Mandhu College (MC), Avid College (AC), and MI College. Among these, AC and MI colleges offer teacher education courses for Early Childhood Education (ECE), while MNU, VC, and IUM offer teacher education for both primary and secondary school level teachers (Rasheed, 2017).

Teacher education programs offered in the Maldives are nominally accredited prior to their commencement by the Maldives Qualification Authority (MQA) but there is no formal monitoring of the accredited teacher education programs conducted by the institutions (Rasheed, 2017). Thus, it is up to the institution to decide how the training programs are carried out. With regards to the incorporation of ICT in the teacher training program, most of the teacher education programs are mandated to have at least one separate module on ICT. However, as mentioned earlier, there is no specific policy on how ICT should be incorporated into the teacher education program or how the module should be taught. Therefore, the skills student teachers acquire from the module is entirely dependent on the lecturer/s that take up the module. Thus, the basic training student teachers acquire is mainly dependent on this single module which they study for one semester in their three-year programs. Research has shown that the integration of technology does not happen over a short period of time. Teachers need contextually meaningful training to become familiar with how to use different kinds of technologies for learning and the opportunity to model the technology, monitor student progress in behaviour, motivation, and assessment (Moeller & Reitzes, 2011). Therefore, to achieve this level of integration, there is a need for ICT programs that deliver teacher training in a way that can facilitate teachers to connect to specific classroom practices or engage them in a community of professional practice that ensures ongoing development (Williams, 2017). At present, there is limited information available on Maldivian pre-service teachers' TPACK and how they are trained to integrate ICT within pre-service teacher education programs. In fact, the ESA 2019 report identified this as a critical knowledge gap, and thus, specific strategic directives have been recommended in the report to address these issues (Ministry of Education, 2019). Thus, to match the training with expected technology implementation outcomes, it is crucial to establish empirical measures to assess teachers' technological pedagogical content knowledge to better address the gaps in teachers' knowledge and competence in integrating technology in their pedagogical practices.

2.4.4. Educational policies on ICT in the Maldives

Research has shown that for technology implementation projects to succeed in schools, national-level ICT policy strategies and guidelines setting the vision and rationale for such initiatives are critical (Yuen & Hew, 2018). These can guide goal setting and strategic directions on how education systems can introduce technology (Yuen & Hew, 2018). Over the last decade, there have been significant developments regarding ICT policies in the Maldives. One indicator used to measure the general level of ICT development in a country is the ICT Development Index (IDI). The International Telecommunication Union (ITU) uses the ICT Development Index (IDI) as a unique benchmark to measure ICT development in countries across the world. It comprises 11 indicators on ICT access, use, and skills, subscales (UNESCO, 2018b). According to UNESCO (2018b), the Maldives has a record of number one internet penetration among South Asian nations with an IDI of 5.04, at 86th rank, the highest score amongst the South Asian countries.

With regards to ICT implementation, the Maldivian Government has formulated policies to increase ICT coverage throughout the country (Kinaanath, 2013) and currently has 100% telecom coverage throughout the nation, with internet service on most inhabited islands (Ministry of Education, 2019). Technology is also incorporated into the education and learning systems at public schools and institutions. Moreover, the ESA 2019 report indicates that technology is now widely used for distance learning to deliver education, especially in remote islands and has thus impacted not only the quality of education but accessibility as well (Ministry of Education, 2019). This fast proliferation of computers and the internet has facilitated many technology initiatives in the country's education system. Consequently, many schools have invested in Smart boards, projectors, and LCD TVs in classrooms (Ministry of Education, 2019).

Furthermore, as mentioned, one of the key competencies in the Maldivian national curriculum framework (NCF) is 'Using Technology and Media' throughout all the key stages of education (NIE, 2014). As a direct strategy to meet the NCF requirements in providing innovative and quality education, the MoE introduced its first ICT in Education Master Plan (ICTE-MP1) from 2015 to 2018 (MoE, 2015). The ICTE-MP1 had ten key deliverables:

1. A national study on the state of ICT in education in the Maldives;
2. All teachers trained in ICT literacy and ICT pedagogy-integration;
3. All schools met the MoE standard on ICT equipment;
4. A national education portal providing all schools access to quality teaching and learning materials;
5. All schools have their own ICT in education development plans;
6. All Teacher Resource Centre (TRCs) upgraded;
7. School curriculum and student assessment updated to integrate ICT;
8. Distance education courses accredited for the continuing professional development of in-service and pre-service teachers;
9. An online educational management information system (EMIS); and
10. An ICT in education conference organized annually.

(Ministry of Education, 2019, p. 169)

The ESA 2019 report recommended further research and analysis to assess the status of the above deliverables. Thus these were revisited in the ESP 2019-2023 report, and new policies (policy number 1.2) were drawn to improve "learning equitably and [reducing] the learning gap, through effective curricula implementation" (Ministry of Education & Ministry of Higher Education, 2019, p. 51). National level strategies were proposed to achieve this policy goal which includes:

- Strengthening technology-based teaching and learning for improved cognitive and non-cognitive learning outcomes, values, skills, attitudes, and competencies (*Strategy 3*).
- Enable access to assistive technology and other appropriate ICT tools for children with exceptionalities and SEN (*Strategy 4*).

(Ministry of Education & Ministry of Higher Education, 2019, p. 51)

As part of meeting the above policy strategies, a second ICT Master Plan (ICTE-MP 2021-2024) is being formulated at the time of this study. The main aim of this second master plan is to achieve the aforementioned policy goal of ESP 2019-2023. These policies and strategies look promising. If carried out as planned, it will help redress much of the technology infrastructure and teacher training needs of government schools in the Maldives. The targets stipulated in the ICTE-MP2 also envisaged that equipping teachers with adequate knowledge and skills needed to leverage digital technologies will maximize meaningful learning benefits for students, as outlined in the National Curriculum Framework (NIE, 2014). Table 2.1 below summarizes critical policy documents that have been developed with a focus on strengthening the ICT in Education policy agenda in the Maldives.

Table 2.1 *National policies related to ICT in Education the Maldives*

Year	**Policy**
2015	ICT in Education Master Plan 2015 to 2018 (ICTE-MP1)
2019	Education Sector Plan 2019 - 2023
2021	ICT in Education Master Plan 2021-2024 (ICTE-MP2) (currently being developed)
2021	ICT competency framework for teachers (Not yet published)

According to Moonen (2008), for ICT initiatives to impact education, they should have three key policy lines. First, policy should '*provide basic knowledge and skills about ICT in education*, by teaching ICT knowledge and skills, or supporting its daily use in schools. Second, the policy should '*facilitate ICT use for the new generation of pupils*' by maximizing internet access in schools, libraries, sports facilities, and homes. Third, the policy should support the '*creation and facilitation of informal teacher networks*' where teachers are considered equals with their pupils regarding attitudes and skills toward ICT.

An evaluation of the ICT policies in the Maldivian education system reveals that they need to address issues at all the three key targets. For instance, the new National Curriculum Framework (NCF) requires teachers to incorporate technology in teaching for all key stages, and the ESP 2019-2023 is drawn to meet the NCF requirements (see ESP 2019-2023 policy *strategy 3 and 4* above). Based on Moonen's (2008) model's first policy line, this means that teachers should possess the ICT knowledge and skills required to meet these policy strategies. However, teachers already in the profession have not had adequate technology training, except for the initial 'Google Classroom' training conducted by the ministry (Ministry of Education, 2021). Thus, the schools were faced with training teachers to develop the pedagogical skills necessary to adopt digital technologies to engage students in meaningful learning as prescribed in the NCF. Although technology training is conducted sporadically in some schools, the lack of suitably qualified professionals (both in terms of technology and pedagogy) hinders most schools from providing the necessary ICT training to their teachers. Thus, a large majority of in-service teachers are in dire need of training (Ministry of Education, 2021).

As for the second policy line, schools have facilities and resources such as internet access in schools and libraries for teachers' and schools' administrative functions (Ministry of Education, 2019). Table 2.2 shows a review of ICT infrastructure in public schools in the Maldives as per the information published on the ESA 2019 report (Ministry of Education, 2019).

Table 2.2 *Digital technology resources and facilities available at schools across the Maldives* (Ministry of Education, 2019)

ICT support provided at schools		
	Teachers	**Students**
Access to computers	90.7%	71.5%
The ratio of computers per teacher/ student	6:1	35:1
Internet access	93.0%	50.6%*
Library collection	75%	
Digital library content	1.7%	
Types of digital technology devices available in the classrooms		
Smart TVs	38.1%	
Projectors	19.6%	
Smart boards	4.2%	
Computer/laptops/iPads	13.1%	
Technology/technical support staff		
Teachers assigned to computer-related subjects	91% expatriates, 64% Male	
Information Technology (IT) technical staff employed	47% schools	

*Note: * Most of these were very limited access*

As seen from Table 2.2, most classrooms lack any technology except for some Smart TVs and projectors. It also shows that the internet access available for students was limited, and more than half the school population lacked IT technical staff. Due to these resource constraints, a majority of schools cannot facilitate the use of ICT for their students (Ministry of Education, 2019). Hence, as evidenced from the literature discussed earlier (see Section 2.2.2), at a national level, policy strategies are required to facilitate schools with the necessary technological infrastructure for technology implementation ventures to succeed (Kozma & Vota, 2014; Lawrence & Tar, 2018; Mow et al., 2017).

The third policy by Darling-Hammond and Richardson (2009) advocates developing strong social networks to foster informal learning through professional learning communities (PLCs) as it is an essential skill for teachers' realising innovations, both within and out outside the school. PLCs or professional learning networks (PLNs), as proffered by Kirkland and Sutch (2009), can allow teachers to collaborate informally, drawing inspiration from each other's ideas and information, for example, from attending external conferences, networking, or observing best practices both within and outside schools. Darling-Hammond and Richardson (2009) argue that national-level strategies must be in place to identify and promote best practices, support the development and dissemination of professional learning resources in priority areas, and develop professional networks for teachers. However, the review of existing national-level policy documents related to ICT (see Table 2.1) in the Maldives indicates no purposeful direction or strategies that facilitate formal or informal teacher networks. Thus, explicit policy strategies are still needed to help schools develop networks where teachers learn informally, and both teachers and students can be considered equals in terms of attitudes and skills towards ICT. For developing countries such as the Maldives striving to introduce technology in their educational system, consideration of these policy challenges is inevitable to their success (Chandra, 2016).

This section reviewed the literature on the status of ICT in education in the Maldives. It provided a brief overview of the context of education in the Maldives (Section 2.4) and the status of ICT in education in the country (Section 2.4.1). It then looked into the technology integration challenges (Section 2.4.2) and how in-service teachers are trained to integrate ICT in their classrooms (Section 2.4.3), followed by a discussion on the educational policies on ICT in the Maldives (Section 2.4.4). This review uncovered several knowledge gaps concerning Maldivian teachers' technology competence and their challenges in integrating digital technologies in their lessons. Thus, the current study sought to address this gap: to understand teachers' knowledge and integration of digital technologies and the factors influencing their technology integration in teaching. Thus, the next section presents the key theoretical models that will guide in getting a better understanding of teachers’ knowledge and integration of technology and its impact on student engagement.

2.5 ROLE OF THEORY IN RESEARCH

An important question the researcher should ask when conducting a study is about the role of theory or how can theory aid in the research. Creswell (2014) defines theory as "an interrelated set of constructs (or variables) formed into propositions or hypotheses that specify the relationship among variables (typically in terms of magnitude or direction)" (p. 51). Creswell (2014) further posits that it can be an argument, a discussion or rationale to explain the phenomena. According to Eisenhardt (1989), theories can be used as a guide for the design and data collection; as an iterative process of data collection and analysis; and also, for the final outcome. This study is explanatory and existing theoretical frameworks are vital to understand the perception of teachers on the TPACK constructs and their teaching practices with regards to technology. Therefore, choosing existing theoretical frameworks help establish different viewpoints, and offers theoretical lenses through which to view the problem.

Theoretical Models for ICT implementation

The overarching aim of this study is to understand how teachers perceived technological knowledge impacts on their capabilities to integrate technologies in teaching and learning. To establish how this occurs in the Maldivian context, theoretical models are needed to probe into how technology integration occurs in their classrooms. Three theoretical models - TPACK, Bloom's Digital Taxonomy, and SAMR model are most relevant to this study.

2.5.1. TPACK

The TPACK framework was originally theorized by Mishra and Koehler (2006) and illustrates seven domains of knowledge that teachers need in order to teach effectively with technology. According to Mishra and Koehler (2008), technology introduces additional variables to the teaching and learning context that mandates teachers to change their practices. Mishra and Koehler (2006) proposed the TPACK framework for integrating technology in teaching and learning. The TPACK model is an expansion of the Pedagogical Content Knowledge (PCK) model theorized by (Shulman, 1987). They critiqued the way the two types of knowledge (content and pedagogy) were treated independently of each other in teacher education programs. Shulman (1987) argued that the content and pedagogy are interrelated and for this reason, teachers should have a deep understanding of the knowledge that is associated with each domain. Mishra and Koehler (2006) adopted this view and extended the argument with a new conceptualization of technological knowledge (see *Figure 2.1*). The framework has been widely used in academic research (Vicente et al., 2018). Since 2009, more than 1100 journal articles and book chapters, almost 300 dissertations and 25+ books have been written with TPACK as the central theoretical construct (Mishra, 2018). A simple Google Scholar search for articles on "technological pedagogical content knowledge" produces around 991,000 results indicating the proliferation of the use of the TPACK framework by scholars.

The TPACK framework focuses on the independent components as well as on the complex interplay of content, pedagogy, and technology knowledge, and how to apply this knowledge within classroom contexts (Willermark, 2018). There are three main components of teachers' knowledge in this model: content, pedagogy, and technology (*Figure 2.1*). In a more recent work, however, Mishra introduced what he termed a 'tweak' to the model produced in 2009 by renaming the outer dotted circle as "Contextual Knowledge" (see *Figure 2.2* Revised version of the TPACK). This introduces a fourth type of knowledge, which he claims, teachers will require in order to effectively integrate technology in their teaching (Mishra, 2018).

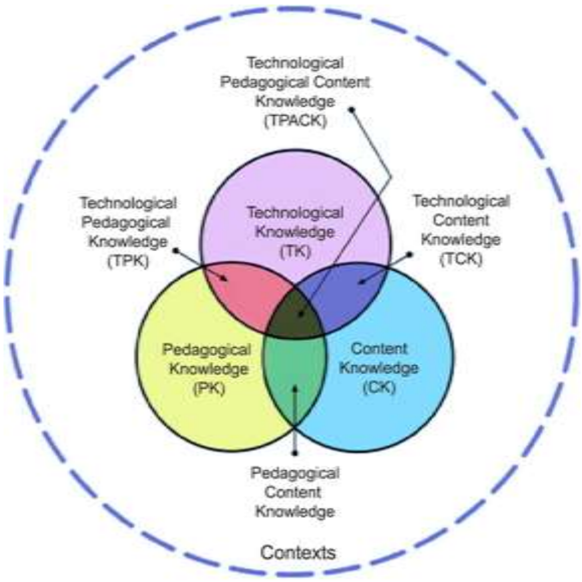


Figure 2.1 Pedagogical and Content Knowledge (Koehler & Mishra, 2009)

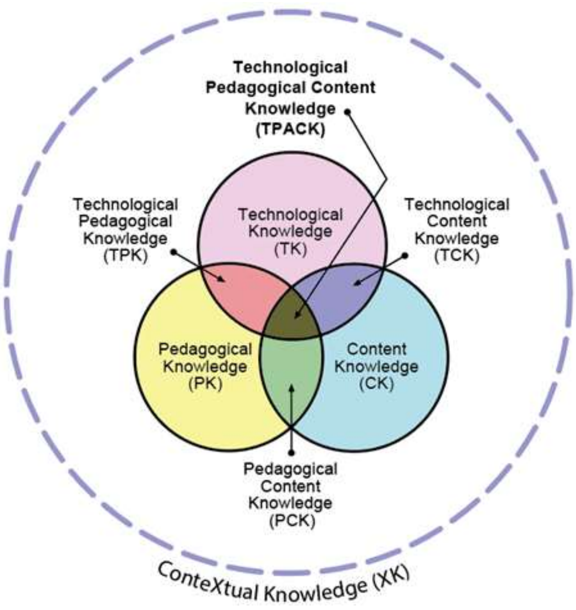


Figure 2.2 Revised version of the TPACK (Mishra, 2018).

Content knowledge (CK)

This refers to teachers' knowledge about the subject matter to be taught. The content to be covered is different for different subjects. For instance, content in middle school science or history is different from the content of an undergraduate course. Knowledge of content is thus unique to the subject taught. Content knowledge comprise concepts, theories, ideas, related to the subject matter. It also includes knowledge of evidence, as well as established practices and approaches in developing content knowledge (Shulman, 1987). The nature of inquiry differs greatly between fields and teachers need a deeper understanding of the knowledge fundamentals in their teaching disciplines (Koehler & Mishra, 2009). For example, in science, this could include scientific facts and theories, the scientific method, and evidence-based reasoning. Likewise, in arts, it could include knowledge of artists and their history, famous paintings and sculptures, and theories for evaluating art (Koehler & Mishra, 2009).

Pedagogical knowledge (PK)

This is the deep knowledge teachers have about the practices or methods of teaching and learning. It includes overall educational purposes, values, and aims. In addition, teachers need knowledge and techniques on how students learn, manage classrooms, plan lessons, and assess students. Teachers strong in pedagogical knowledge can thus aid students to construct knowledge and acquire skills to develop habits of mind and positive inclinations to learning (Koehler & Mishra, 2009). In other words, teachers need knowledge and understanding of the cognitive, social, and developmental theories of learning and how it can be applied in their teaching (Koehler & Mishra, 2009).

Technology knowledge (TK)

This refers to the knowledge about various technologies. It could range from low-tech technologies such as blackboard and chalk to digital technologies such as the Internet, tablet, interactive whiteboards, and learning management systems (Koehler & Mishra, 2009). This includes knowledge and skills to operate digital technologies (e.g., operating systems and computer hardware and software), use web-browsers, email programs, and word-processors. Moreover, knowledge on how to install and upgrade hardware and software, maintain data archives are required. Most importantly, to be cognizant of the ever-changing technologies, teachers need to constantly refresh their knowledge in this domain (Koehler & Mishra, 2009). In addition, teachers should have a broader understanding of information technology to apply it productively at work and everyday lives. Teachers also need to have the ability to recognize the applicability of information technology to achieve the desired goal and adapt as and when required. This requires a deeper understanding of technology for information processing, communication, and problem-solving (Koehler & Mishra, 2009).

Pedagogical content knowledge (PCK)

PCK is the specific knowledge on how to teach the content. Pedagogical content knowledge is different for different content areas. Often, students' current understanding and the methods to be adopted depict the salience of the content. (Mishra & Koehler, 2008). Teachers need this knowledge to represent the subject matter in multiple ways and modify subject content for alternative conceptions based on students' prior knowledge (Mishra & Koehler, 2008). This is consistent with Shulman’s (1987) approach to PCK as knowledge of pedagogy applicable to teaching specific content. PCK covers teaching, learning, curriculum, assessment, and reporting. It includes conditions for promoting learning and the links between the curriculum, assessment, and pedagogy. Teachers, therefore, need to understand the common misconceptions and ways of addressing them. It is also important to make connections among different content-based ideas, students' prior knowledge, and alternative teaching strategies for effective teaching (Koehler & Mishra, 2009).

Technological content knowledge (TCK)

TCK refers to the knowledge of technology required to create new representations for specific content. Therefore, it requires teachers to recognize how technology and content influence and constrain one another. Thus, teachers need to understand how subject matter can be changed by the application of technology or vice-versa (Mishra & Koehler, 2008). Certain content limits the types of technologies that can be used, or sometimes, the choice of technologies used can afford or constrain the content that can be taught (Mishra & Koehler, 2008). Furthermore, technological tools may offer greater flexibility to navigate across these representations. Thus, teachers need an understanding of various technology applications to decide the one that best addresses the subject matter and the learners. By using a specific technology, teachers can change the way learners practice and understand concepts in a specific content area.

Technological pedagogical knowledge (TPK)

Technological pedagogical knowledge refers to the knowledge of how a particular technology can be used in teaching. It requires an understanding that using technology may change the way teachers teach; the pedagogical affordances and constraints of technological tools and the contexts within which they function. For example, consider how technology can afford new forms of pedagogy through Moodle (courseware) to structure online discussions. Through the discussion forum, students can post their opinions and also view what their peers post. The benefit here is, teachers can control when students can view posts from their peers. This affords changes in the pedagogy which would not have been possible with face-to-face classroom contexts. Teachers can get students to share their unique viewpoints, free from external influences or prior responses. It also gives students opportunities to think about (and post) their ideas (Mishra & Koehler, 2008).

Technological pedagogical content knowledge (TPACK)

Technological Pedagogical Content Knowledge is about the interaction of content, pedagogy and technology knowledge (Mishra & Koehler, 2008). TPACK knowledge is required by teachers to integrate technology into their teaching in any content area. Specifically, teachers should have an understanding of the complex interplay between the three basic components of knowledge (CK, PK, and TK) to teach content effectively using appropriate pedagogical methods and technologies. According to Mishra and Koehler (2008), effective teaching with technology requires TPACK and is characterized by a number of competencies. These include understanding how to represent concepts using different pedagogical techniques through technologies to teach content. It also encompasses teachers' knowledge of students' understanding of the complex subject matter to guide them to learn those concepts through multiple representations using technology. Finally, it includes an appreciation of different learning theories, identifying students' prior knowledge, and helping them develop new epistemologies or strengthen old ones via technologies (Mishra & Koehler, 2008).

Contextual Knowledge (XK)

Contextual Knowledge (XK) refers to the teacher's knowledge of the context (Mishra, 2018). This includes teachers' awareness of the technology resources available for teaching and learning; the contextual environment (e.g., classroom, school, district, and state level factors) they have to operate (Mishra, 2018). The justification Mishra (2018) offers for making the outer circle a separate domain was because teachers need to know their context to integrate technology effectively. The implication is that when bounded, contextual knowledge is something teachers can act on, and therefore can be changed or developed. Mishra (2018) argues that this knowledge is of critical importance because lacking knowledge of their contextual environment could inhibit their attempts at technology integration (Mishra, 2018).

Teaching and learning with TPACK

Technology has become an inevitable part of schools and has the potential to improve the teaching and learning process. Thus, to effectively integrate technology in teaching, Mishra and Koehler (2006) argue that teachers need to understand the relationship between the three types of knowledge: content, pedagogy, and technology. Moreover, research shows that most teachers use technologies merely to transmit knowledge, without thinking much about the implication of using technologies on their students' learning (Harris et al., 2009). According to Koehler et al. (2007), this intricacy is due to teachers' limited understanding of how to integrate their content knowledge into their pedagogical and technological knowledge. Thus, the literature suggests that teachers require these skills in order to connect the three types of knowledge: content (What to teach?), pedagogy (How to teach?), and technology (What technologies to use?) (Mishra & Koehler, 2006).

According to Handal et al. (2014), effective application of the TPACK framework can enable teachers to deliver creative instruction and engage students in meaningful learning. Such an approach can immerse students as producers rather than consumers of knowledge. TPACK, due to its three dimensions, can be a valuable model to appraise teachers' perception of their ICT capabilities based on their own pedagogical affordances, technical capabilities, and content delivery (Harris et al., 2009). A substantial body of research discusses teachers' TPACK perceptions and their application in the integration of digital technologies in teaching and learning across various context (Altun & Akyildiz, 2017; Archambault & Crippen, 2009; Barac et al., 2017; Castéra et al., 2020; Chaipidech et al., 2022; Graham et al., 2009; Jang & Tsai, 2013; Kim et al., 2021; Koh et al., 2014; Lin et al., 2013; Long et al., 2020; Owusu et al., 2015a; Rahman et al., 2017; Redmond & Peled, 2019; Sahin, 2011; Tokmak et al., 2013; Yanış & Yürük, 2021) (see Appendix B).

Despite the numerous studies, how TPACK is conceptualized and interpreted varies among scholars, as evidenced by the various modification the framework has seen over the past 15 years (Lee et al., 2022). The conceptualization of TPACK began with the extension of Shulman's (1987) PCK model (Cox & Graham, 2009; Niess, 2005). Since then, some have taken a transformative stance, viewing it as a distinct category of knowledge (Angeli & Valanides, 2009; Yeh et al., 2014), while others adopted an integrative approach where the interaction between technology (TK), content (CK), pedagogy (PK) and the intersections of these domains (TPK, TCK, PCK) are studied in specific contexts (Koehler & Mishra, 2009; Mishra & Koehler, 2006).

Some foregrounded the content-specific nature of TPACK (e.g., literacy, mathematics, science, social studies (Schmidt et al., 2009; Tokmak et al., 2013); science (Graham et al., 2009; Jang & Tsai, 2013; Lin et al., 2013; Owusu et al., 2015b); Chemistry (Chen & Wei, 2015); mathematics (Niess, 2012); English Language teachers (Sahin, 2011), whereas others emphasized the value of TPACK in terms of pedagogical approach such as lesson planning (Harris & Hofer, 2009); practical teaching (TPACK-P) (Yeh et al., 2014); constructivist-oriented use of ICT for self-directed and collaborative learning (Koh et al., 2010; Schmidt et al., 2009); TPACK for Meaningful learning (Chai, Koh, Tsai, et al., 2011; Koh et al., 2014). The context has also been studied in understanding teachers' TPACK, though only a few studies have made empirical efforts to investigate it as an additional component of teachers' knowledge (Jang & Tsai, 2013; Mishra, 2019; Porras-Hernández & Salinas-Amescua, 2013).

TPACK studies focusing on specific technologies are also extensive (e.g., TPACK for web-based learning (Archambault & Crippen, 2009; Lee & Tsai, 2010); online-line teaching (Archambault & Barnett, 2010); technology-interactive Whiteboard (Jang & Tsai, 2012); screen-casting video lessons using iPads (Bonafini & Lee, 2021); and technology-robotics (LEGO) for STEM (Rahman et al., 2017; Yanış & Yürük, 2021), with scholars recently beginning to focus on more novel technologies such as robotics, AI and VR is yet to be explored. Some conceptual works in this area include teachers' TPACK for teaching and learning AI for K-12 (Kim et al., 2021) and teachers' TPACK development for integrated STEM learning using an AI-based personalized learning system (Chaipidech et al., 2022).

These studies suggest that having a strong TPACK can give teachers the ability to appraise ICT tools based on their pedagogical and content capacity. This can help foster students' cognitive engagement and can be assessed using the revised Bloom's taxonomy (Anderson et al., 2001). The measure of a student's cognitive engagement is very important. Existing research shows the use of ICT tools in and of themselves result in very small educational value. The focus is mainly on rote learning activities, instead of helping students develop desired problem-solving or critical thinking skills that promote meaningful learning (Shuler, 2009). Learning with ICT, therefore, should be student-centred (Traxler, 2011). It is also crucial for the ICT tool to have high levels of cognitive interactivity to engage learners. Such levels of cognitive interactivity can be assessed within the context of Bloom's digital taxonomy (Churches, 2008) wherein learners are engaged at various levels of achievement (Handal et al., 2014).

2.5.2. Bloom's Digital Taxonomy

As described earlier, teachers need to have technological pedagogical and content (TPACK) knowledge required when teaching using ICT. That is, teachers should have the ability to appraise technology tools based on their pedagogical and content capacity as well as for their capacity to foster student's cognitive engagement (Handal et al., 2014). Moreover, it is also crucial that teachers are able to employ the selected ICT tools to engage learners and attain high levels of cognitive interactivity. One useful framework that can be used to assess levels of cognitive interactivity is Bloom's digital taxonomy (Churches, 2008) wherein learners are engaged at various levels of achievement (Handal et al., 2014).

Bloom's taxonomy is a theoretical framework for learning and was first published in 1956 by Benjamin Bloom and his team (Anderson et al., 2001; Bloom & Krathwohl, 1956). Since its publication, Bloom's Taxonomy has been extensively used by educators to teach and assess students' learning at both lower order thinking as well as higher-order thinking (Cardullo et al., 2015). Based on observable behaviours of learning objectives, the taxonomy provides educators with the first systematic classification of the process of thinking and learning (Cardullo et al., 2015).

By applying its multi-tiered classification of learning objectives, teachers and test developers can set assessment tasks aligned to Bloom's cognitive levels (Cardullo et al., 2015) that can be used to assess student's learning (Saldana, 2015). Learning objectives are statements of learning that have an action (verb) and an object (noun) (Saldana, 2015). The key components of the learning objectives are the object which describe the knowledge learners are expected to understand or construct, and the verb which refers to the actions involved in the cognitive process (Anderson et al., 2001). The original Bloom's Taxonomy was considered as a way to categorize planned skills that are required in learning environments. It identified three domains of learning activities: cognitive, affective and psychomotor (Bloom & Krathwohl, 1956).

In 2001, Bloom's taxonomy was revised by Anderson and his team to address the requirements of 21st-century students and the changes were brought to the categories in terms of the terminology, structure and emphasis (Anderson et al., 2001). The terminology changes included the modification of the six major categories of the cognitive domain from noun (knowledge, comprehension, application, analysis, synthesis and evaluation) to verb (remembering, understanding, applying, analysing, evaluating and creating) and the level of complexity as shown in *Figure 2.3* below (Cardullo et al., 2015).

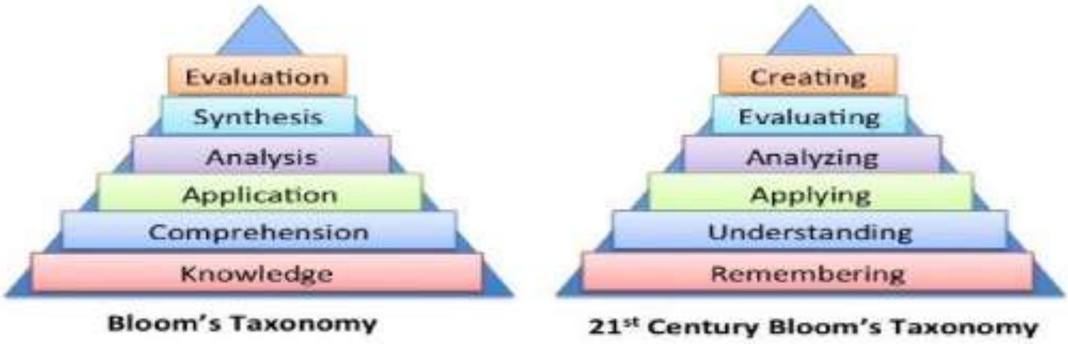


Figure 2.3 Bloom's taxonomy and Bloom's revised taxonomy (Anderson et al., 2001)

In addition to the cognitive dimension, the revised Bloom's Taxonomy also has a knowledge dimension. The knowledge dimension includes factual, conceptual, procedural, and meta-cognitive processes. The cognitive process dimension proposes learning that is associated with remembering, understanding, applying, analysing, evaluating, and creating (Krathwohl, 2002; Krathwohl & Anderson, 2010). Shown below are the meanings associated with each of the six levels of learning as explained by (Krathwohl, 2002)

- Remember: getting relevant information to mind from long-term memory by Retrieving and Recalling.
- Understand: Use various forms of communication such as speaking, writing and graphical to determine the meaning of instructional messages. This includes: Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, and Explaining
- Apply: carrying out a procedure by applying appropriate method to a given situation. This includes: Executing and Implementing
- Analyse: breaking down the problem to its constituent parts to uncover/ rediscover the connections and then organize the relationships between the parts, or to the entire structure or its purpose. This includes Differentiating, Organizing, Attributing
- Evaluate: Making decisions based on criteria and standards. This includes Checking and Critiquing.

- Create: Bringing components together to form a whole coherent or a novel or original product. This includes: Generating, Planning, Producing

The Revised Bloom’s Taxonomy framework can be used to show step-by-step learning that occurs within the cognitive domain (Krathwohl, 2002). Teachers can apply the taxonomy to analyse the syllabus or a unit, categorize learning tasks based on the learning objectives, evaluate the relationship between assessment and learning/teaching activities, or scrutinize the teaching materials (Krathwohl, 2002). While the elements in the Revised Bloom’s Taxonomy cover many of the activities and objectives that require higher-order thinking skills, Churches (2008) argued that it does not address the new objectives presented by the emergence and integration of ICT into the classroom.

Consequently, in 2007, Churches updated Bloom’s Revised Taxonomy to create Bloom’s Digital Taxonomy (Churches, 2008). In this multi-tiered model (*Figure 2.4*) developed by Churches, he incorporated new ways of learning facilitated by technology. He added examples of ICT activities/tools at all cognitive levels. Churches (2008) argued that the level of cognitive skills developed is not dependent on the technological tool, but rather on how the tool is integrated to facilitate higher level learning and understanding (Cardullo et al., 2015). Therefore, educators need to focus on how technology is integrated into the lesson instead of focusing on a specific technology.

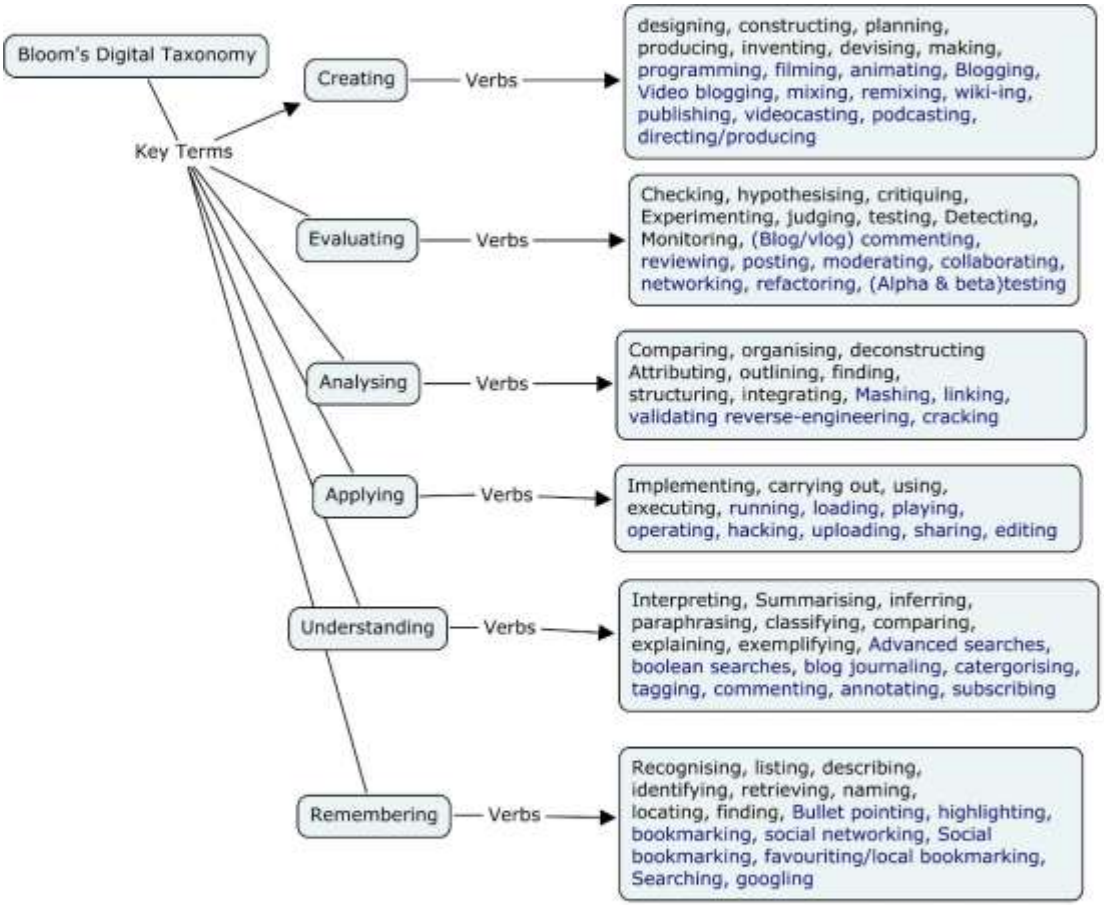


Figure 2.4 Bloom's digital taxonomy (Churches, 2008)

Bloom's Digital Taxonomy, therefore, provides a context for measures of cognitive engagement which could be articulated smoothly to learning using ICT (Handal et al., 2014). To fully engage students at different levels of cognitive interactivity, Bloom's digital taxonomy developed by Churches (2008) can be applied as it can enable teachers to plan activities in order to get learners engaged at various levels as proposed by the taxonomy (Churches, 2008). Moreover, Bloom’s Digital Taxonomy is more applicable for this study as it is already familiar and easy for the teachers to understand, while it also is detailed enough to provide valuable insights into the cognitive processes that are necessary to inculcate different levels of thinking skills in learners (Dagostino et al., 2015).

Adopting Bloom's Digital Taxonomy, therefore, provided a framework to understand cognitive engagement. Such knowledge give researchers an insight into the use of technology to facilitate learning and through the application of different thinking skills (Cardullo et al., 2015). However, the question is, how can ICT promote higher level learning and the development of critical thinking skills and what technology models are applicable to integrate technology into teaching? These are questions that this study seeks to answer through this research and lead to the next key theoretical proposition, the SAMR model that was found crucial to achieve the aims of the current study.

2.5.3. SAMR

Integration of digital technologies into practice involves constant change. One ideal framework that can be used to study the changes in teacher practice and student engagement with technology integration is the SAMR model proposed by (Puentedura, 2012). SAMR stands for substitution, augmentation, modification, and redefinition (see *Figure 2.5*). The model illustrates how teachers process a task when adopting educational technology (Cardullo et al., 2015).

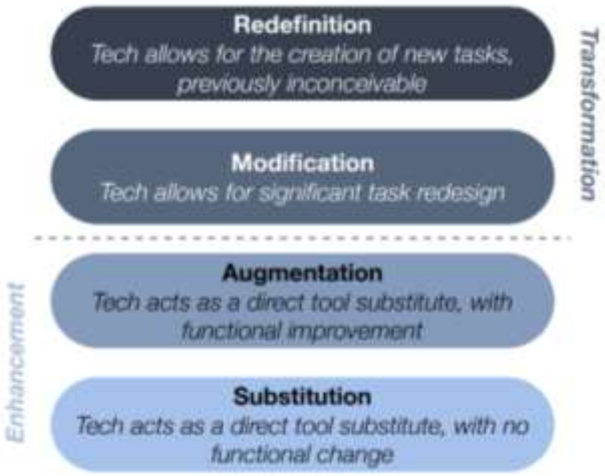


Figure 2.5 SAMR model (Puentedura, 2012)

Substitution

Substitution involves the use of technology for a task that could have been accomplished without using technology. Thus, substitution does not result in any functional change. With substitution, technologies are used to enhance rather than transform the activity. For example, a tablet can be used to read an e-book instead of a physical book. In this situation, the physical book is substituted with an e-book using technology. The activity is a substitution activity and does not provide any functional improvements whether the book was read online or not. Consequently, the student would learn the same objective or concept using either format (Tangney & Bray, 2013). Similarly, the use of word processor instead of pen and paper to create a short story would be at the substitution level. This technology-driven instructional activity is only a minor enhancement which could have easily been completed without the use of technology. The only measurable benefit might be work that is easier to read as opposed to a hand-written story (Fabian & MacLean, 2014). It does not result in any functional improvement to the learning process.

Augmentation

Augmentation involves technological improvement for a task that could be completed without technology. Technology utilized here serves as a substitute for other learning activities; with some functional improvements (Puentedura, 2012). For example, in a first-grade classroom, instead of a teacher reading out a story, students can use hand-held devices to simultaneously read and listen to individual digital stories. The hand-held device is used to augment the reading task in this situation (Hamilton et al., 2016). Both augmentation and the substitution level comprise the enhancement phase. That is, the technology-driven instructional activities within these two levels help to enhance the learning process, but do not alter or change the learning outcome (Patton, 2015). Similarly, when using the word processor, the embedded functions such as editing features, spelling and grammar checks, insertion of images/graphics and document layout can be considered as augmentation as these features can improve the final document produced. The difference between substitution and augmentation is the use of features to improve the product; but only minimal development of learning skills (Keane et al., 2016).

Modification

Modification involves significant re-design of existing pedagogies and learning activities using technology. That is, at this level, the use of technology changes the task. For example, in a secondary science class, an instructor can change how students learn about light by using computer simulation. This is a modification where instead of using a normal diagram, the concept of light traveling is explained using an interactive computer simulation of light with variables students can change (Hamilton et al., 2016). Similarly, following from the previous example of a word document, rather than completing a story as a static word-processed document, the writing can be shared electronically through a blog or a wiki, opening it up to a wider audience. This can create opportunities for students to work on the task individually or collaboratively, both synchronously in class time, as well as asynchronously out of class resulting in task transformation (Keane et al., 2016).

Redefinition

Finally, redefinition involves the creation of a completely new task not possible without the technology. For example, a teacher can ask students to work either individually or collaboratively to create and present their work on a given topic by using a range of ICT tools such as audios, videos, internet, etc. instead of getting them to write a normal essay (Hamilton et al., 2016). Thus, using technology, students can research and share their findings in order to find a common solution. Their writing can be transformed into a range of multimedia where they collect, communicate, and disseminate their information. This final level is difficult to precisely describe as what is possible using technology is constantly being redefined (Keane et al., 2016). In both Substitution and Augmentation modes, digital technologies are tools for enhancing pedagogy while both modification and redefinition result in the transformation of pedagogy (Puentedura, 2012).

The SAMR model can be used to examine each learning task to determine the depth and complexity of technology integration. The model presented by Puentedura (2012) complements the TPACK as it allows teachers to think about how technology can be used to enhance or transform the learning experience. The SAMR model also emphasizes the role of teachers and the degree of their engagement with digital technologies for learning (Oxnevad, 2013). As a result of an increasing number of schools adopting technologies, and the endorsement of the SAMR model by Apple, its use has been fairly widespread in schools (Oxnevad, 2013). The SAMR model can be used to describe how teachers process a task when adopting educational technology and also to analyse the changes resulting from technology integration in a lesson (Cardullo et al., 2015). Because of its simplicity, the model is commonly used by teachers to question and refine their practices (Harmandaoğlu Baz et al., 2018). Thus, in this study, the TPACK framework, BDT and SAMR can help teachers conceptualize digital technology integration in their practice (Harmandaoğlu Baz et al., 2018).

2.6 GAPS IN LITERATURE

The reviewed literature underscores that technology on its own does not make a difference, teachers do (Barak, 2014; Beauchamp et al., 2015; Chandra, 2020; Chandra & Lloyd, 2020; Darling-Hammond & Richardson, 2009; Koh et al., 2016; Mishra & Koehler, 2006; Owusu et al., 2015b; Spiteri & Chang Rundgren, 2020; Vanderlinde & van Braak, 2010). It is also noteworthy that digital technologies can positively impact teaching and learning, provided they are embedded effectively. Consequently, issues concerning the knowledge and skills teachers require for the effective use of digital technologies to enrich student engagement and learning should be considered when investments in ICT in education are being made. Against this premise, the reviewed literate identified three significant gaps.

First, although the TPACK framework has been used widely across different contexts to examine teachers' knowledge in integrating technology, the reviewed literature revealed that no published work thus far exists that has investigated teachers' TPACK within the Maldives. This is considered a gap in the literature, especially when attempting to understand teachers' knowledge concerning technology integration within SIDS contexts.

Second, despite several studies emphasizing the importance of TPACK knowledge for technology integration, none of the published work investigated its effect on teachers' technology integration and the perceived impact on students' cognitive engagement. Hence, two more models: SAMR and Bloom's Digital Taxonomy (BDT), were reviewed. The SAMR model describes how particular technology/ies can be used to enhance or transform pedagogy, while BDT conceptualises how students' cognitive engagement is impacted due to technology use. While these models are clearly described within literature, a single framework that conceptualises teachers' knowledge and practices to realize successful student engagement and learning was not found and is considered the second gap.

The third gap relates to the lack of literature on an in-depth understanding of the influences or the factors affecting Maldivian in-service teachers' integration of digital technologies in their classroom instruction. The following section elaborates the conceptual model adopted to investigate the research questions that helped address these gaps.

2.7 CONCEPTUAL FRAMEWORK AND JUSTIFICATION

As stated above, several important implications resulted from the literature review carried out in this chapter. First, the limited ways in which teachers use technology tools undermines the potential attributed to these technologies and raises the need to study teachers' knowledge and integration of technology. Secondly, it became evident that numerous factors influence the integration of technology in schools. These factors are and will continue to be heightened due to the dynamics of these technologies (Blundell, 2017). Third, although numerous research studies have been conducted in developed societies, the reviewed literature has shown that studies on teachers' TPACK and technology integration within developing countries, especially in SIDS such as the Maldives, are limited. Moreover, even within the existing literature, no published work is available that discussed teachers' TPACK, how technology is integrated, the perceived impact on students' cognitive engagement, and the factors that influence teachers' technology integration within one single study.

Thus, in light of the review and the theoretical background presented in this chapter, the study proposed the following conceptual framework (see *Figure 2.6*) to capture teachers' TPACK and integration of digital technologies in the context of the Maldives. The framework adopted the TPACK (Mishra & Koehler, 2006), SAMR (Puentedura, 2012), BDT (Churches, 2008) and model of contextual levels (Porras-Hernández & Salinas-Amescua, 2013) as theoretical lenses to guide the research (see *Figure 2.6*).

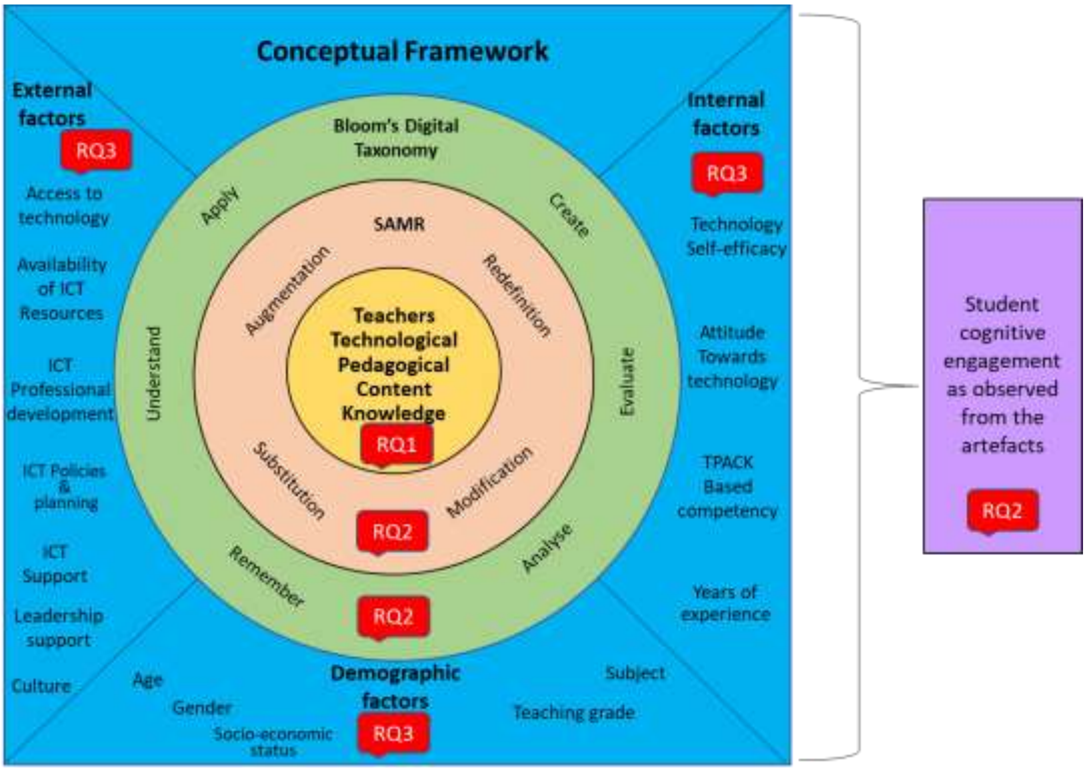


Figure 2.6 Conceptual framework for the proposed study

Adoption of the theories mentioned above to conceptualise teachers' integration of digital technologies in the Maldivian context was critical in this study for several reasons. First, one predominant determinant for successful ICT implementation that came up within the reviewed literature repeatedly is the critical role of the teacher, particularly, teachers' knowledge and skills pertaining to technology integration (Al Harbi, 2014). Therefore, ways to measure this knowledge become vital to transform teachers' pedagogical practice when adopting technology in their teaching. A useful theoretical model found within the literature that conceptualizes the knowledge teachers require for successful technology integration is the TPACK framework proposed by Mishra and Koehler (2006), which was discussed earlier in this chapter (Section 2.5.1). According to the TPACK theory, teachers must have a coherent understanding of how ICT can be combined with subject matter knowledge and teaching strategies to raise the chances of effective learning (Mishra & Koehler, 2006).

The TPACK model proposes three types of knowledge: content (subject area), pedagogy (teaching knowledge), and technology (technology background) that are required for successful technology integration in teaching and learning (Mishra & Koehler, 2006). Thus, using the TPACK framework helped address research question one (*RQ1*): to understand teachers' perception of the knowledge domains related to technology integration within the classroom. In addition, this gave the researcher an overview of teachers' perception of how these knowledge types are intertwined for teaching using the various kinds of technologies.

Second, while the TPACK model is helpful to conceptualise teachers' knowledge requirements, it does not allow one to identify how teachers use this knowledge and technology for students' learning transformation. This is a limitation, especially when the overall goal of the educational reforms in many countries is to develop an effective ICT-based learning environment that can result in learning transformation for students. Hence, investigating how teachers integrate technology into classroom practices and examining the perceived impact on student learning and engagement is valuable when discussing the effectiveness of ICT initiatives. A relevant model for this purpose is the SAMR model (Section 2.5.3) developed by Puentedura (2012). The ultimate goal of introducing technologies into classrooms is to transform student learning, and the SAMR model can provide a valuable lens to investigate how teachers use the technology that results in the enhancement or transformation of learning. Although Puentedura (2012) identifies the significance of the degree of enhancement or transformation resulting from technology use, how students' learning is affected is still not explicitly evident in SAMR. One way to assess student learning is through their level of cognitive engagement. Blooms' Digital Taxonomy (Section 2.5.2), proposed by Churches (2008), provides a useful tool to explore the impact technology can have on students' cognitive engagement levels and is considered appropriate to this investigation.

Thus, the use of SAMR and BDT aided in addressing the second research question (*RQ2*). The SAMR model helped the researcher assess how teachers integrate technology and the resultant student learning. The model aided to describe how teachers process a task when adopting educational technology and also to analyse the changes (enhancement or transformation) resulting from technology integration in lessons (Puentedura, 2012). Bloom's Digital Taxonomy offered a way to assess students' cognitive engagement ensuing from teachers' adoption of the technology in their teaching (Churches, 2008).

Finally, the reviewed literature highlighted a wide array of factors influencing teachers' technology integration in their teaching (Neira et al., 2018; Porras-Hernández & Salinas-

Amescua, 2013). While these factors are described in diverse contexts, a single framework that conceptualizes the importance of these factors in teachers' adoption of technologies in teaching, especially in the Maldives, is not found in the literature. Therefore, exploring the factors affecting technology implementation among Maldivian in-service teachers offers valuable insights to identify the challenges teachers face with ICT integration and determine the interventions that may help address these issues. Furthermore, in-service teachers’ current practices with technology integration in their classroom teaching are confined by the contextual environment in which they worked. That is, consideration had to be made on how teachers' pedagogical practices were affected due to their demographic characteristics, knowledge and competence, and other external environments. Thus, the model of contextual levels proposed by Porras-Hernández and Salinas-Amescua (2013) helped conceptualize research question three (*RQ3*) by gaining an in-depth understanding the antecedents and contextual factors that influence their current practices when integrating technology in their classroom teaching. Together, these models complement each other by allowing the researcher to evaluate teachers’ TPACK, how technology is adopted by teachers, whether the use of technology enhances or transforms students’ learning experience and if so, the level of students’ cognitive engagement, and the factors that impact teachers in their technology integration endeavours.

2.8 CHAPTER SUMMARY

In this chapter, a critical review of the literature on ICT in education was presented. The chapter began with a brief background to ICT in education, the benefits of and the barriers to technology integration in teaching and learning. This was followed by an exploration of the literature on the requirements (teacher-related and non-teacher-related) for effective ICT implementation. Next, it looked into the use of ICT in education in general, narrowing it down to contexts similar to the Maldives and then specifically in the Maldivian context. Literature from the different contexts evidenced improvement in teachers' pedagogical practices due to technology integration; but was mainly used to complement their existing strategies rather than to transform teaching (Zheng et al., 2016). The review also found enhanced student engagement and higher-order thinking resulting from various technology implementation initiatives (Lindsay, 2016; Schmidt et al., 2009). However, its impact on student achievement shows mixed results (Zheng et al., 2016). Moreover, in conceptualising the requirements for successful technology integration, this review identified several factors, and these influences were quite diverse. Thus, these factors were discussed under internal factors related to teachers and those that were non-teacher related.

The chapter then examined various theoretical models relevant to teachers' knowledge and integration of digital technologies. More specifically, it scrutinized the technological pedagogical and content knowledge (TPACK), a model that has been used widely across different contexts to examine teachers' knowledge in integrating technology. It also looked into existing models on how digital technologies are integrated and how it impacts teaching (SAMR) and student engagement (BDT).

The reviewed literature clearly showed a limited number of studies investigating teachers' TPACK and technology integration within a SIDS context, and no published work thus far exists in the Maldivian context. The review thus identified the research gaps within the literature and underlined the groundwork for this research.

In light of the review and the theoretical background presented above, the chapter concluded with the conceptual framework proposed to capture teachers' TPACK and technology integration (see Figure 2.6). This framework uses theories on teachers' knowledge and integration of digital technologies (i.e., TPACK, SAMR), student cognitive engagement (i.e., BDT), and factors affecting technology integration (contextual level models) as theoretical lenses to investigate the research questions. Justifications were provided for adopting the theories and models selected for this research. The next chapter discusses the research methodology adopted to answer the research question (s).

Chapter 3: Research Design

3.1 INTRODUCTION

The previous chapter reviewed the literature regarding teachers' technology integration in teaching and learning. In particular, the chapter explored the definitions of technology integration for educational purposes, the theories surrounding various technology integration models, the factors that influence teachers' technology integration efforts, and then looked into the status of technology integration in the Maldivian schools, and the context for the current study. Finally, it framed the theoretical and conceptual framework that aided to address the key research questions of this study which includes:

RQ1: What are Maldivian in-service teachers' perceptions of the constructs of TPACK (Technological Pedagogical and Content Knowledge)?

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

An explanatory mixed-method research design was adopted to address the above research questions, and data was gathered from Maldivian in-service secondary grade teachers teaching in grades 9 and 10. This chapter outlines the research design adopted in addressing the above-mentioned research questions and justifications for the methodological choices that were made. The chapter is divided into three key sections. The first section introduces the chapter (Section 3.1) and then looks into the philosophical worldviews (Section 3.2) that guided the research approach for the current study. The second section articulated the explanatory mixed-method research design (Section 3.3) and justification for choosing this particular design. The next sections elaborated the phases (Phase I - quantitative phase (Sections 3.4 to 3.10) followed by Phase II - qualitative phase (Sections 3.11 to 3.14) of the study. Under each phase, the population and sampling, the data collection procedure, and the data analysis techniques are explained. This is followed by data triangulation (Section 3.15), including a summary of the methods used to ensure trustworthiness and credibility and the researcher's role. Next, the ethical considerations for the research are described (Section 3.16), followed by a summary of the chapter (Section 3.17).

3.2 PHILOSOPHICAL WORLDVIEWS

The decision of a research methodology adopted is dependent on the researchers' philosophical beliefs and world views they hold regarding the truth of knowledge (ontology) and how this knowledge can be created (epistemology) (Denzin & Lincoln, 2018). These philosophical views have a significant impact on the whole research process, including the way data are collected and analysed and how the findings are interpreted and reported (Merriam, 1998). Ontology refers to what exists or the fundamental nature of reality (Neuman, 2014). Epistemology is a theory of knowledge that concerns what is considered acceptable knowledge in a particular discipline (Bryman, 2006). Epistemological assumption can be regarded as associated with the nature of knowledge and the methods of acquiring that knowledge. It is about knowing the world around us or making valid claims about truth (Neuman, 2014). Therefore, ontology understands knowledge, and epistemology explains the study and the acceptance of valid knowledge.

Behavioural science and social research books reveal several paradigms or philosophical worldviews on how this can be achieved. Several distinct philosophical worldviews are identified within the literature. Three commonly distinguished worldviews include positivism (or post-positivism), interpretivism (or constructivism), and pragmatism. Nevertheless, as the ultimate goal of any research is the research outcome, there is no difference in fundamental goals in any worldview. Each tries to enhance their understanding of the world (i.e., the truth/reality) and make generalizations of their results either objectively (positivists), subjectively (interpretivist), or with multiple realities (pragmatist) while minimizing bias (Steenhuis & Bruijn, 2006). There is a common understanding that the research processes used and the researched objects are closely related (Weber, 2004). Thus, in finding the truth, due to researcher preconceptions, it is believed that there will be bias and fallibility in the results (Weber, 2004). Hence, while appreciating these differences, researchers in all camps seek to improve shared understanding of the world through their approach. Thus, it can be said that there is no one best research approach to finding answers to their research question/s. It depends on their philosophical beliefs and the related theoretical approaches or research strategies. Thus, in line with these philosophical worldviews, and the aims of the current study, the researcher adopted a pragmatic approach to seek knowledge on the proposed research question.

Philosophically, pragmatism is a movement that moves past the paradigm wars by offering a logical and practical alternative (Johnson & Onwuegbuzie, 2004). As Patton (1990) stated, pragmatism arose from actions, situations, and consequences rather than antecedent conditions concerned with understanding the problem and recommending solutions. Unlike the stringency between positivism and interpretivism, pragmatic researchers focus on solving the research problem by using all approaches at their disposal (Creswell, 2014). Thus, instead of fixating on one system of philosophy and reality, pragmatic researchers' worldviews on truth are based on multiple realities (i.e., subjective, objective, and inter-subjective). They give high regard for reality (Onwuegbuzie et al., 2009). As a result, their epistemological belief in the truth about knowledge is constructed and based on the world's reality as lived and experienced (Onwuegbuzie et al., 2009). For them, truth is what works at the time and is not based on whether reality is independent of the mind or within the mind (Creswell, 2014). In other words, pragmatism focuses on the "consequences of actions" and being "problem-centred", "pluralistic", and "real-world practice-oriented" (Creswell, 2014). Thus, Pragmatism allowed the researcher to adopt multiple methods, with different worldviews and assumptions, and different forms of data collection and analysis to answer the research questions of this study (Creswell, 2014).

3.3 RESEARCH DESIGN

In order to decide on a research design, a clear understanding of possible research approaches becomes necessary. An approach is defined by Creswell (2014) as "plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis and interpretation" (p. 3). Creswell (2014) distinguishes between three main approaches to research in social science: *qualitative, quantitative, and mixed-methods* approach. Qualitative approaches stem mainly from interpretivist/constructivist worldviews, whereas quantitative approaches tend to be based on a positivist/post-positivist worldview and mixed-methods on a pragmatic worldview (Creswell, 2014).

A qualitative approach is explained by Creswell (2014) as an exploration carried out to understand the meaning that individuals or groups ascribe to as a social or human problem. This involves emerging questions and procedures, collecting data typically in the participant's setting, and analysing data inductively to build themes. Finally, by making interpretations of the data, researchers give meaning to the findings. By contrast, quantitative research approaches can be applied when testing objective theories to examine relationships among variables. Specific instruments can be used to gather numerical data to measure these variables, which can then be analysed using statistical procedures (Creswell, 2014). Mixed-methods research refers to the integration of both approaches in one single study. The aim is to obtain a more comprehensive understanding of the research problem than would have been possible by using either approach alone (Creswell, 2014). Notably, the distinction between qualitative and quantitative research is not dualistic but a continuum, with mixed-methods found in the middle (Newman & Benz, 1998). Researchers adopting mixed-methods research can draw solutions from quantitative and qualitative assumptions to address the 'what' and 'how' types of research questions (Creswell, 2014). However, as a philosophical perspective for mixed-methods studies, it is crucial for the researcher to carefully focus on the research problem and apply appropriate approaches to derive knowledge about the problem (Morgan, 2007; Patton, 1990; Tashakkori & Teddlie, 2010). The adoption of mixed-method research approaches should be carried out to offer the best opportunities for answering the research questions.

Several typologies exist for classifying and identifying types of mixed-method research designs (Creswell, 2014). Amongst others, three basic mixed-methods design identified by Creswell (2014) include 'convergent parallel mixed-methods', 'explanatory mixed-method' and 'exploratory mixed-methods. With the convergent parallel mixed-methods design, researchers collect both quantitative and qualitative data concurrently but analyse them separately, and then compare the results to see if the findings confirm or disconfirm each other (Creswell, 2014). Both explanatory and exploratory designs consist of two phases of data collection. The main difference is in the priority given to the sequence on the type of data collected first. In exploratory design, researchers first explore the problem by collecting qualitative data and follow it up with quantitative data to validate the qualitative findings. One of the main aims of adopting this design is to help develop better measurements to see if data from the smaller group (in the qualitative phase) can be generalized to a larger population (in the quantitative phase). For example, data can be collected through interviews or focus groups first, and then the survey instrument is developed based on the findings from the qualitative data gathered. It is then validated and administered to a sample in a population. This approach is beneficial for researchers in situations where there are no existing instruments to study a phenomenon.

On the contrary, in an explanatory design, quantitative data are collected in the first phase, and qualitative data are collected in the second phase. The quantitative results typically inform the participants who can be selected purposefully for the qualitative phase and the types of questions that will be asked to expand quantitative findings further. The aim is to help the researcher explain the findings of the quantitative results by using in-depth qualitative data. For instance, a researcher could first collect survey data in the first phase, analyse it, and then follow it up with qualitative interviews to help explain the survey responses. This approach can be appealing to individuals with a solid quantitative background or from fields relatively new to qualitative approaches (Creswell, 2014).

3.3.1. Research design for the current study

Having outlined the distinction between different research approaches, the focus now returns to the approach/es most suited to answer the research question at the heart of this study. Patton (2002) claims that almost all research designs have limitations due to resource constraints, capabilities, purposes, possibilities, creativity, and judgments from the people involved. Creswell (2013), too, contends the complexities inherent in selecting an approach. In addition to the worldview, design, and methods, other factors such as the research problem, researcher's personal experiences, and the audience(s) for whom the report is written play a significant role in the selection of an approach. Creswell (2013) argues the importance of selecting an approach that can answer the research question well. In this regard, he states that if the research question involves (a) the identification of factors that influence an outcome, (b) the utility of an intervention, or (c) understanding the best predictors of outcomes, then the best approach would be quantitative. The quantitative approach is also most suitable if the researcher's aim is to test a theory or explanation (Creswell, 2014). By contrast, research where a concept or phenomenon needs to be explored and understood in-depth as there is limited previous research or it is not clear to the researcher the key variables to examine, then a qualitative approach is more appropriate (Creswell, 2014). Lastly, if the research question is of such a nature that neither of the above-mentioned approaches can yield a comprehensive answer, a more appropriate approach would be to adopt mixed-methods research (Creswell, 2014).

The current study sought to address answers on both the ‘what’ (in-service teachers’ TPACK perception, factors affecting use of technology) and ‘how’ (in-service teachers’ integrated technology in their classroom teaching, it impacts on their student’s engagement) of the problem being investigated. Thus, based on these aims and against the literature on research designs (Creswell, 2014), the best approach to investigate the research questions in this study was by adopting a mixed-method design. The next section explores why a mixed-method design based on pragmatic philosophical views was most applicable to the study.

3.3.2. Justification for the choice of a mixed-method approach

Mixed-methods as a new methodology originated around the late 1980s and early 1990s within diverse fields, including education, management, social and health sciences (Creswell, 2014). Consequently, it can be said that the establishment of mixed-methods as a research paradigm is fairly recent. Its growth in popularity was fuelled by the pragmatic shift that came about with its value of data triangulation from multiple sources and multiple inquiry tools, allowing to gain diverse perspectives on a research problem (Creswell, 2014). Mixed-methods design allows integrating qualitative and quantitative research and data within one research study to produce a more comprehensive output.

Using mixed-methods can help the researcher get a more comprehensive understanding of the problem being studied by addressing both the 'what' (quantitative) and 'how or why' (qualitative) types of research questions (Cohen et al., 2007). For instance, quantitative methods can identify the key characteristics, while qualitative methods can help in-depth investigations of the relationship between those dimensions (Fraenkel & Wallen, 2009). Furthermore, as mentioned earlier, the findings from mixed-method studies can be more comprehensive as they allow the researcher to compare, corroborate, and triangulate the data to see if a variety of methods (surveys, interviews, documents) converge on common understandings (Bryman, 2006; Johnson & Onwuegbuzie, 2004). Therefore, mixed-methods are beneficial for gaining a more complete, comprehensive, and holistic picture of a multifaceted situation than using either one of the approaches alone (Creswell, 2014). Adopting a mixed-method design can also help minimize researcher bias (that arises from pre-existing notions or assumptions) as it allows for multiple sources of data (e.g., surveys). This can be used to confirm (or disconfirm) qualitative interviews and anecdotal evidence to converge both qualitative and quantitative analyses to help enhance the validity of inferences and conclusions drawn (Lund, 2012).

Thus, to get a more comprehensive understanding of in-service teachers' TPACK perception, how they use technology in their classrooms and how it impacts students' cognitive engagement in selected Maldivian schools, this study adopted a mixed-method approach that involved the collection of both qualitative and quantitative data. The mixed-method approach was deemed most suitable for this study as it allowed the researcher to get an overview of teachers' overall TPACK perception through quantitative data initially. Then, qualitative data helped gain a deeper understanding of teachers' integration of technology in classroom teaching, how it impacted students' cognitive engagement, and the factors that influenced teachers' technology integration efforts. Moreover, mixed-methods helped strengthen the findings as the quantitative findings were triangulated using the qualitative data (Creswell, 2014).

Based on the earlier discussion on the type of mixed-method approaches, it is evident that the research design chosen should logically link the data and the conclusions to the study's research questions (Creswell, 2014). This study adopted an explanatory mixed-method design to gather and analyse quantitative data first, followed by qualitative data in two consecutive phases within one study (Ivankova et al., 2006). Thus, to understand teachers' TPACK, quantitative (survey) data were gathered and analysed first. Based on the results of the quantitative data, qualitative methods (interviews and document reviews) were applied for a more in-depth understanding of how teachers use technology and the perceived impact on students' cognitive engagement. The qualitative data collection methods also shed light on the factors that influenced teachers' technology integration efforts. Adopting an explanatory mixed-method design helped enhance the credibility of the findings by allowing to compare and corroborate the data obtained from quantitative (survey) and qualitative (interviews and document reviews) methods used in the study (Creswell, 2014). In addition, a mixed-method design enabled the use of case studies to explore in-depth how teachers adopted technology in their classroom (Gillham, 2000).

3.3.3. Case study design

Case study research design helps researchers look into a problem and explore it in-depth (Feagin et al., 1991). According to Gillham (2000), the problem being explored could be an individual, a group, an organization, a country, an event, a process, or a period of time. Case studies have been used widely, particularly in social research, and increasingly, in education. Case studies are designed to bring out the details from the participants' viewpoint through multiple sources of data (Gillham, 2000). Stake (1995) describes a case study as either intrinsic (the researcher has an interest in the case), instrumental (the case helps understand what is not immediately apparent to the observer), or collective (a group of cases). According to Yin (2009), a case study can either be exploratory (a preface to social research), explanatory (causal investigations), or descriptive (development of a descriptive theory prior to commencing the project).

Case studies can be conducted as single-case or multiple-case applications. However, the criteria for selecting cases must maximize what can be known within the timeframe available for the study (Gillham, 2000). A critical factor in the case studies is the unit of analysis and can include a system, an individual, or a group of individuals (Gillham, 2000). Case studies tend to be selective, focusing on one or two fundamental issues to understand the examined problem. Case studies use perspectives from multiple sources in their analyses. This means that researchers should consider the voice and perspective of the relevant participants and their interaction. The use of multiple data sources also helps with triangulation and confirming the validity of the processes (Yin, 2014). Moreover, as the data generated in case studies often reverberates from a broad cross-section of readers, it facilitates a greater understanding of the phenomenon being studied (Stake, 1995).

Case studies can be used to confirm or challenge theories or represent unique/extreme cases (Yin, 2014) where an observer may have access to a previously inaccessible context. It can be holistic or embedded, with the latter possible when the same case study involves more than one unit of analysis (Tellis, 1997). Thus, the 'explanatory' case study design proposed by Yin (2014) was the basis for this mixed-method case study. This involved selecting multiple cases using the 'collective' case study approach by Stake (1995) to understand the phenomenon being investigated in-depth. Thus, each selected participant, their technology integration practices, impact on students' cognitive engagement, and the influences on their technology integration efforts were considered a 'case' in this study.

The explanatory mixed-method case study approach allowed for the study to be conducted over two phases. A macro-level survey was conducted during phase one, which provided a global picture of Maldivian in-service teachers' TPACK at a national level. In phase two, micro-level, multiple case studies were used to understand teachers' technology use in their classrooms at selected school/s. These two phases are explained next. First, the quantitative phase (Phase 1) is described, followed by the qualitative phase (Phase 2). For each phase, the data collection methods, the sources of data, instrument design, validity and reliability, the pilot study, recruitment of samples, data collection procedure, and data analysis procedure are explained separately.

PHASE 1: QUANTITATIVE PHASE

The first phase of data collection sought to understand teachers' perception of TPACK and aided in answering the question 'What are Maldivian in-service teachers' perceptions of the constructs of TPACK?' A large-scale quantitative survey was used in this phase to get an overview of the in-service lower secondary grade (grades 9 and 10) teachers' TPACK perceptions across the country. The findings from this phase aided the researcher in selecting cases (participants with different levels of TPACK perception) for the in-depth study in phase two of the inquiry. The following section details the processes that were followed in phase 1.

3.4 QUANTITATIVE SURVEY DATA COLLECTION

An online survey was used to identify teachers' perceptions across the TPACK constructs (see Appendix C). Surveys are widely used to examine populations' behaviours, perceptions, or characteristics, test hypotheses, and analyse tendencies (Creswell, 2014). A primary advantage of surveys is that they allow the researcher to collect data from a large group of participants scattered across a wide geographic area within a short time frame and cost-efficiently. In addition, surveys reduce researcher bias as respondents can fill questionnaires at their leisure without the researcher's presence while maintaining anonymity (Creswell, 2014). However, it is acknowledged that there may still be some researcher bias in the survey creation and item development. Moreover, with self-rating surveys, ‘leniency bias’ may occur if participants rate their perceptions highly; especially if they are unaware of their incompetence, resulting in overconfidence (Dunning et al., 2003; Maderick et al., 2016; Schmid et al., 2021; Staus et al., 2014). Thus, researchers do caution readers when interpreting survey results. Nonetheless, surveys provide a way to gather a large amount of data quickly that can be used for descriptive, inferential, and explanatory analysis to ascertain relationships between different survey variables (Cohen et al., 2007).

Thus, to gather data on teacher's TPACK, a survey-based questionnaire (explained in Section 3.5) was used. Because the teachers are distributed across a wide geographic area, the online surveys allowed the researcher to collect information from multiple sites more cost-effectively and within a reasonable timeframe. One of the main limitations of surveys, however, is the slow or limited response rate. In order to meet the required sample size, surveys had to be sent to the maximum number of participants meeting the sampling criteria (i.e., all the teachers in grades 9 and 10 of government schools in the Maldives). Furthermore, the data collection process was prolonged as more time was needed to plan and distribute the questionnaire, with sufficient response time (with reminders) allocated for respondents to complete and return the surveys.

3.5 INSTRUMENT DESIGN

A review of the literature was carried out to identify any existing instruments applicable to the current study. The review included questionnaires from TPACK related theses and journal articles. From the review, the most appropriate instrument applicable for this purpose was the TPACK survey developed by Koh et al. (2013). They examined the perceptions of technological pedagogical content knowledge (TPACK) for meaningful learning among primary, secondary, and junior college teachers in Singapore. However, the basis for their instrument was the first TPACK survey instrument developed by Schmidt et al. (2009) to measure elementary teachers' TPACK for literacy, numeracy, science, and social studies. This version of the instrument contained 47 items to examine teachers' perception of the seven constructs of the TPACK framework developed by Mishra and Koehler (2006) (see Section 2.5.1). Since the original TPACK by Schmidt et al. (2009), the instrument has been used to examine teachers' perception of TPACK in different contexts, but with many variations to the original instrument.

For the current study, Koh et al.'s (2013) instrument was considered most appropriate due to a number of reasons. First, the instrument has been validated and used in several international contexts including Singapore, Taiwan, and China (Chai, Koh, & Tsai, 2011; Chai, Koh, Tsai, et al., 2011; Koh et al., 2014; Koh et al., 2010; Liang et al., 2013; Liu et al., 2015). Second, the internal reliability (Cronbach α = 0.89-0.95) and construct validity of the instrument concerning all the seven TPACK factors were already established. Also, since the instrument measures teachers' TPACK for facilitating meaningful learning (Koh et al., 2013; Koh et al., 2014), it was contextually relevant to assess the TPACK perception of in-service teachers in the current study, especially considering the emphasis given in the new National Curriculum Framework to inculcate 21st-century skills in students, by harnessing digital technologies (NIE, 2014). This requires teachers to have the knowledge and skills to develop students' competencies by integrating technology-supported pedagogies that engage students in self-directed, collaborative, and meaningful learning (NIE, 2014).

The instrument comprised 29 items that measured teachers' perceptions of TPACK on seven types of knowledge required when integrating technology (Koh et al., 2013). The seven knowledge constructs include:

1. Technological knowledge (TK)—knowledge of technology tools.
2. Pedagogical knowledge (PK)—knowledge of teaching methods.
3. Content knowledge (CK)—knowledge of the subject matter.
4. Technological content knowledge (TCK)—knowledge of subject matter representation with technology.
5. Technological pedagogical knowledge (TPK)—knowledge of using technology to implement different teaching methods.

6. Pedagogical content knowledge (PCK)—knowledge of teaching methods concerning subject matter content.
7. Technological pedagogical content knowledge (TPACK)—knowledge of using technology to implement teaching methods for different types of subject matter content (Mishra & Koehler, 2006)

Each construct had several statements rated on a five-point Likert-type scale where 1—strongly disagree, 2—disagree, 3— neither agree nor disagree, 4— agree, 5— strongly agree. In addition, it also collected teachers' demographic information such as age, gender, education level, frequency of using technology, grade, nationality, and subject taught. A copy of the survey instrument is provided in Appendix C.

3.6 VALIDITY AND RELIABILITY OF THE QUESTIONNAIRE

The instruments chosen for data collection must pass the validity and reliability tests before they can be considered suitable measures (Dikko, 2016). Reliability refers to the consistency of a measure. That is, answers from one administration of an instrument to another and one set of items to another should be consistent (Heale & Twycross, 2015).

Reliability of the quantitative instrument can be ensured when a measure is achieved, and if it consistently measures the concept, it is supposed to measure without bias (Heale & Twycross, 2015). Cronbach's alpha can be used to assess the reliability of the scales during the pilot study (Cronbach, 1951). For an item to be considered reliable, the scales should yield at least a value of 0.7 or more for Cronbach's alpha, and the Corrected item-total Correlation values should be 0.3 or more (Pallant, 2013). Any weak items from the instrument are deleted after examining the scale's validity until the desired score can be achieved. The original instrument by Koh et al. (2013) has shown a high reliability score (Cronbach $\alpha = 0.89$-0.95), which was considered appropriate for their analysis. A similar range of reliability scores was obtained for the seven scales in the current study and is discussed later under the 'pilot study' (see Section 3.7).

Validity ensures "whether or not a method's findings represent the phenomenon they are supposed to measure" (Hesse-Biber, 2010, p. 100). Establishing the scale's validity is crucial to draw meaningful and valuable inferences from survey instruments (Creswell, 2014). There are three significant types of validity in quantitative research instrument; *content, predictive or concurrent, and construct* validity. *Content* validity checks if the instrument adequately covers all the content it should concerning the variable/s or construct it was designed to measure

(Heale & Twycross, 2015). *Predictive* validity checks whether the results correlate with other results. For example, a score of high self-efficacy related to performing a task can be used to predict the likelihood of a participant completing the task (Heale & Twycross, 2015). *Construct* validity refers to the extent to which a research instrument (or tool) measures the intended construct and thus can be used to draw inferences about test scores related to the concept being studied. For example, a person's high score on a survey that measures anxiety can be used to identify if this person truly has a high degree of anxiety (Heale & Twycross, 2015).

Since the current study used a well-established and standardized instrument, the TPACK survey (see instrument design), the content, criterion, and construct validity have already been established (Koh et al., 2013). However, as the study was conducted in a different context, it was crucial to establish the instrument's validity in the new context and is explained in more detail later in this chapter (see Section 3.10.2).

3.7 PILOT STUDY

Since the questionnaire was an adapted version of the TPACK survey from Koh et al. (2013), it was essential to identify and address any problems in the instrument in relation to the Maldivian context. A printed version of the questionnaire was distributed to seven participants who were known to the researcher. Ten questions (questions on CK1, CK2, CK3, PCK1, PCK2, PCK3, TCK1, TCK2, TCK3, and TPACK1) in the original version of the instrument inquired about 'first teaching subject (CS1)'. Some participants asked for clarification about this since, in the Maldives, it is not compulsory for all the teachers to teach more than one subject and therefore did not have a first and second subject. Thus, to minimize confusion, these questions were modified with '*teaching subject*' instead of '*first teaching subject*' as shown in Table 3.1 below:

Table 3.1 *Revisions brought to original survey questions*

Original survey	Current survey
Q1-I have sufficient knowledge about my *first teaching subject (CS1)*	Q1-I have sufficient knowledge about my *teaching subject*
Q2- I can think about the content of my *first teaching subject (CS1)* like a subject matter expert	Q2- I can think about the content of my *teaching subject* like a subject matter expert

The above procedure thus helped fine-tune the instrument. Furthermore, to make it less mentally taxing for participants and increase their response rate and quality as suggested by Groves et al. (2009), the seven-point Likert scale in the original version was changed to a five-point Likert scale ranging from 'strongly agree' to 'strongly disagree'. Next, the survey instrument was piloted on a small sample of individuals. The goal was to assess the time required to fill in the questionnaires, test the clarity of the survey questions and check to see if any further amendments were needed (Creswell, 2014). A hard copy of the questionnaire was sent to 35 participants that met the demographic requirements of the study, and 31 questionnaires were completed and returned. Of these, the 30 fully completed questionnaires were entered into SPSS to test for the scale's reliability. The items and their corresponding constructs of this step of the pilot study are detailed in Table 3.2.

Table 3.2 *Items and their corresponding constructs*

Construct	**Indicator**	**α**
Technical knowledge	TK1, TK2, TK3, TK4, TK5, TK6	0.715
Content knowledge	CK1, CK2, CK3	0.693
Pedagogical knowledge	PK1, PK2, PK3, PK4, PK5	0.813
Pedagogical content knowledge	PCK1, PCK2, PCK3	0.905
Technological content knowledge	TCK1, TCK2, TCK3	0.607
Technological pedagogical knowledge	TPK1, TPK2, TPK3, TPK4, TPK5	0.878
Technological pedagogical and content knowledge	TPACK1, TPACK2, TPACK3, TPACK4	0.871
Overall scale reliability		0.879

As seen from Table 3.2 above, the Cronbach alpha for the overall scale was above 0.7. Thus, the instrument's reliability was considered to be reasonably high (α=0.879). Moreover, the Cronbach's of each construct were over the cut-off value of 0.7 (Field, 2018) except for TCK (α = 0.607). However, considering the strong theoretical basis of TCK as an important indicator of teachers' TPACK (Koehler & Mishra, 2009), the researcher decided to retain all the seven items.

3.8 POPULATION, SAMPLE, AND SAMPLING

The population comprises all the members of a particular group the researcher is interested in and would like to generalize the study results to (Fraenkel & Wallen, 2009). The target population for the quantitative survey was the entire population of in-service teachers teaching in lower secondary grades (grades 9 and 10) in Maldivian government schools, and the sampling frame was a list of teachers employed at these grades with the Ministry of Education. According to the Statistical Yearbook 2018, the total population of in-service teachers employed in this category was 2984. The Australian Bureau of Statistics (ABS) online software was used to calculate the sample size required for the survey. Based on ABS criteria, a minimum sample size of 341 (with 95% confidence level and 5% margin of error) was required to meet sampling criteria for a population of 2984 (Cohen et al., 2007) (see Table 3.3).

Table 3.3 *Target sample size for each locality*

Regions	Population	Proposed sample
Male' city	676	77
Atolls	2308	264
Total	**2984**	**341**

Note: Calculation based on the School Statistics 2018, Maldives, p.38 (Ministry of Education, 2018)

To obtain the required sample size, all teachers that met the selection criteria were invited to participate in the survey, to yield maximum response rate and to get a broader understanding of the problem being investigated in various school contexts across the country. As the survey was online, all the participants who completed and returned the survey forms were used for the study. This resulted in 486 responses to the online survey (greater than the proposed sample size) and indicated a response rate of 16.3%.

Among the 486 participants, more than half the respondents were males (54.8%), with the majority in the 31-to-40-year range age category. More than half (56.9%) of the respondents had 1 to 10 years of teaching experience, and 11% of the participants did not have a teaching qualification. Subjects taught by participants varied, with the highest number of participants teaching Mathematics (19.8%) and English language (18.6%). Participants from the remaining two compulsory subjects were low (Dhivehi language (7.4%) and Islamic studies (5.8%)). Interestingly, several respondents were found to teach more than one subject. The majority of the teachers also taught to both grades (71.5%). Amongst the respondents, 36.7% were local (Maldivian) teachers. The others were expatriates (Indian (62.1%) and Sri Lankan (1.2%)). The participants were almost equally distributed across the three regions (North (38.6%), Central (36.5%), and South (24.9%)) of the country. The majority of the respondents belonged to local island schools, with only 12.6% from schools in the capital city, Male'. More details of participants' demographic information can be found in Appendix D.

3.9 QUANTITATIVE SURVEY DATA COLLECTION PROCEDURE

Upon ethical clearance (from the QUT), the researcher obtained official approval from the Ministry of Education to conduct the study. The survey for phase one was conducted online using the QUTs online Key Survey application. This proved beneficial as it helped reach many of the participants from island schools and distributing printed survey forms would have been costly and time-consuming.

Access to the participants was made with assistance from the Ministry of Education. An email and covering letter were sent to potential participants, informing them that their participation in the survey was voluntary. Additional information explaining the reasons for the survey, the benefits, and the risks of participating was also provided to make an informed decision. Participants were assured of confidentiality and anonymity of their responses and that a filled and submitted survey form was indicative of their consent. A note thanking the teachers for their time was attached with the email in appreciation of their participation. Participants were also requested to provide contact details if they were interested in volunteering for the follow-up interview.

To access the survey, the participant had to click the QUT Key survey link that was sent with the email. All the surveys were self-administered, and teachers could pause and return to the survey later. Two months were allocated for the data collection for this phase, which began in May 2019. At the end of the first month, a reminder email was sent, and another month was given to increase the response rate.

3.10 QUANTITATIVE SURVEY DATA ANALYSIS PROCEDURES

The quantitative survey data analysis was conducted in two main steps: preparing and organizing the data for analysis; then conducting the data analysis. The first step involved exporting the data into a statistical program, coding and assigning numeric scores to the data, cleaning, and accounting for missing values, and checking for outliers and normality of the data distribution. The second step involved performing the actual data analysis. This included analysing the scale's reliability and validity and descriptive and inferential analysis to answer the research questions (Gay, 2009). The following sections discuss these steps in more detail.

3.10.1. Preparing the data set

Data from the online version was exported from QUT Key Survey directly into the Statistical Package for the Social Sciences (SPSS) software version 25.0 for Windows to preserve the integrity of the data. Only the researcher has access to these data. Once in SPSS, the data were coded and cleaned by screening for any missing data and any other kinds of anomalies before performing analysis. Preparing and organizing the data for analysis involved coding and assigning numeric scores to the data, cleaning, accounting for missing values, and checking for outliers and normality of distribution of the data.

3.10.1.1.Coding the data

A systematic coding process is necessary to perform any quantitative analysis (Gay, 2009). This was done by assigning a numeric score (value) for each response category of choices provided for each question on the survey. For example, questions with categorical answers "what is your gender?", a score of 1 for males and 2 for females were used. This exact procedure was followed for all the questions with nominal data. Likewise, for questions with scale data (interval or continuous), scores ranging from 1 to 5 were assigned. For example, for TPACK scale items, the answers ranged from "strongly disagree" to "strongly agree", and scores from "1" to "5" were used to code the answers for these items. Table 3.4 shows an example of the coding system, and the codebook maintained for easy reference on how the recording was done (Creswell, 2014).

Table 3.4 *Sample* codebook *for the survey questionnaire*

Variable Name	**Variable abbreviation**	**Variable type**	**Description**
Respondent Number	R.ID	nominal	Identification number assigned to each participant, 1-485
Gender	Gender	nominal	1 = Male, 2 = Female
Nationality	Nationality	nominal	1=Maldivian’, 2=Indian, 3=Sri Lankan

3.10.1.2.Data cleaning - checking for missing values and outliers

Missing values

Dealing with missing values is an essential first step of survey analysis (Creswell, 2014). In this study, the survey was conducted online, and participants had to respond to an item before they progressed to the next. This meant all 485 cases were data complete, and since there were no missing values in the dataset, no further action was necessary to address the issue. Hence, the issue of missing values did not arise in this study.

Outliers

Checking for outliers is important because they can significantly distort the means and standard deviations (Hair, 2014). Outliers are cases with extreme values, very different from the majority, and thus, can significantly impact the statistical analyses such as correlations, t-tests, ANOVA, MANOVA, and regression analysis (Cohen et al., 2007). Moreover, the presence of outliers can bias the sample estimates and adversely impact the degree of the linear relationship between two variables (Osborne & Overbay, 2004). Outliers can also negatively impact exploratory and confirmatory factor analysis, both based on the correlation coefficient (Brown, 2015), and must be handled to produce accurate results free from bias and reduce the errors of inferences (Osborne & Overbay, 2004).

One method of checking for outliers is to visually inspect the data distribution by examining the histograms and box plots. Data points that sit out on the extremes indicate the existence of outliers (Pallant, 2013). Also, statistical methods such as converting values to standardized scores (z scores) can help detect possible outliers (Hair, 2014). For large samples (with cases ≥ 200), any variable with a z score higher than four is considered possible outliers (Hair, 2014).

The visual inspection of the histograms and box plots showed no anomalies. The standardized scores (z scores) produced for the independent variables (teachers' age, number of years of teaching, the experience of using technologies in teaching) and the dependent variable (the TPACK scales) were within the acceptable range of -4.0 to +4.0 (Hair, 2014), except for the variable 'Experience of using technologies in teaching". As shown in Table 3.5 below, this variable had a minimum of -4.37055 and a maximum of 1.47690.

Table 3.5 *Descriptive Statistics of the Standardized Scores for the Dependent and Independent Variables*

	N	Minimum	Maximum
Zscore: (Age)	486	-1.76458	2.73600
Zscore: (No of years teaching)	486	-1.36789	3.81512
Zscore: (Experience of using technologies in teaching)	486	-4.37055	1.47690
Zscore: (TPACK total score)	486	-3.30936	1.74365
Valid N (listwise)	486		

To address issues with outliers, the dataset was checked by sorting the z-scores of the variable 'Experience of using technologies in teaching' in ascending order to identify the outlier case (case 434) that had a z score value below 4. The respondents' answers to other questions were also checked and it was found that most of the fields were filled with irrelevant answers. Therefore, based on this evidence, and to eliminate issues that might arise later in the analysis from the presence of outliers, the case was completely removed from the dataset that resulted in an acceptable z score for all the variables (< 4). This resulted in 485 complete cases ready for statistical analysis.

3.10.1.3. Normality of data distribution

Screening the study variables for normality was important; especially if inferential analysis on the data were to be conducted (Pallant, 2013). Normality is one of the important assumptions of inferential analysis, such as analysis of variances, correlation, or regression analysis. Failure to satisfy this assumption could result in distorted relationships and statistical significance tests (Pallant, 2013). For the current study, the distribution of the dependent variables, the TPACK scales were first visually inspected by plotting histograms. A normally distributed data set will have the greatest frequency of cases near the centre of the distribution, and have a bell-shaped curve that is symmetrical on the y-axis (Field, 2018; Pallant, 2013). *Figure* 3.1 below shows the shape of the distribution of the dependent variables.

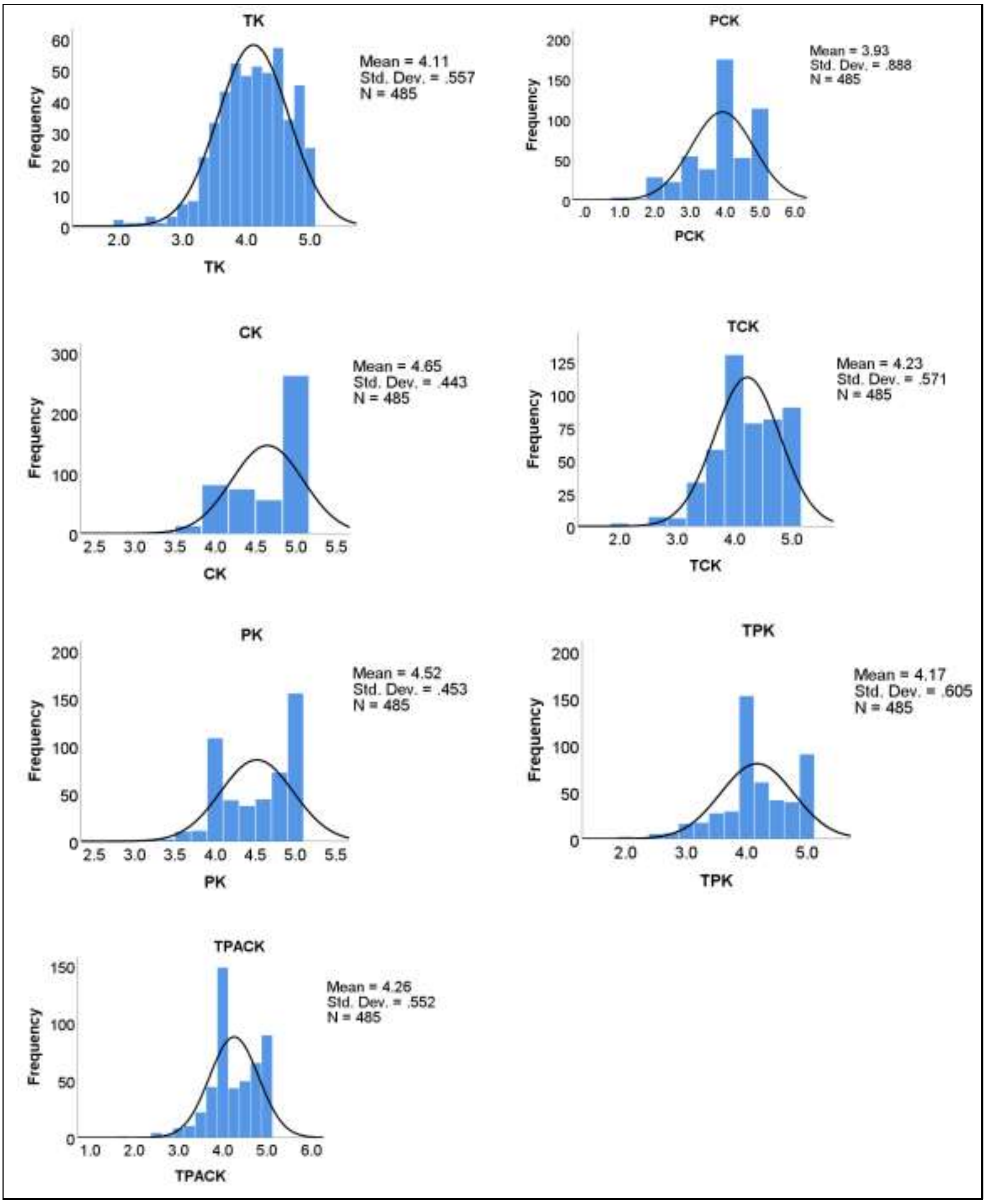


Figure 3.1 Distribution of the dependent variables

The distributions in *Figure* 3.1 above, appeared to be reasonably normally distributed for the seven dependant variables TK, CK, PK, PCK, TCK, TPK, and TPACK. While the histograms give an overall idea of the distribution, judging based on this visual inspection alone is not advisable due to subjective bias. Therefore, combining it with statistical methods can strengthen results (Field, 2018). A number of statistical methods such as inspecting the absolute values of skewness and kurtosis; using the z-scores of the skewness and kurtosis; or using the

Kolmogorov-Smirnov test or Shapiro-Wilk test can be used to test normality (Field, 2018; Tabachnick & Fidell, 2013). With large sample sizes, however, it is not advisable to use z-scores of the skewness and kurtosis, and the Kolmogorov-Smirnov test or Shapiro-Wilk test as they might show non-normal distribution even if for slight deviations (Field, 2013). Thus, absolute values of Skewness and Kurtosis for the seven dependent variables were inspected (see Table 3.6).

Table 3.6 *Skewness and Kurtosis values of the dependent variables (TPACK scales)*

Dependent variables	Count	Min	Max	Mean	St. Dev.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
TK	485	2.00	5.00	4.11	0.56	-0.583	0.111	0.480	0.221
CK	485	2.67	5.00	4.65	0.44	-0.977	0.111	0.182	0.221
PK	485	2.80	5.00	4.52	0.45	-0.521	0.111	0.672	0.221
PCK	485	1.00	5.00	3.93	0.89	-0.748	0.111	0.110	0.221
TCK	485	2.00	5.00	4.23	0.57	-0.511	0.111	0.263	0.221
TPK	485	2.00	5.00	4.17	0.60	-0.558	0.111	0.397	0.221
TPACK	485	1.75	5.00	4.26	0.55	-0.534	0.111	0.590	0.221

As shown in Table 3.6 above, the absolute values of Skewness and Kurtosis were less than 1. The values for skewness ranged between 0.51 to 0.98 and the Kurtosis ranged between 0.11 and 0.67, which indicated an approximately normally distributed data set for the seven dependent variables. Once the data have been cleaned, coded, and tested for missing values, the next step was to validate the survey instrument before conducting descriptive and inferential analysis. The next section explains the procedure and outcome of the factor analysis process that was followed to establish validity of the TPACK scale for the Maldivian context.

3.10.2. Validating the instrument (Factor analysis)

This section aims to provide evidence that supports the validity and reliability of the survey instrument that was used to identify teachers' perception of the TPACK constructs. As mentioned, the instrument used in this study was the TPACK survey that was used by Koh et al. (2013) and administered to practising teachers in Singapore to ascertain their perceptions of the technological pedagogical content knowledge (TPACK). Although the validity and reliability of the instrument were established by Koh et al. (2013) and their team for the Singaporean context, the instrument needed to be validated for the current study because the context was different. Thus, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) was carried to establish the validity and reliability of the TPACK scale. The following section presents the results of exploratory and confirmatory factor analysis (Section 3.10.2.1

and 3.10.2.2), and the construct validity and reliability (Section 3.10.2.3) for the main scales used in the current study.

3.10.2.1. Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) is generally used to design and test scales and instruments in social sciences (Costello & Osborne, 2005). It determines the common factors or interrelationships among a scale's items influencing the variables being measured (Hair, 2014; Pallant, 2013). In other words, it attempts to uncover the sets of items that 'hang together' on a scale (Baoshan et al., 2014). The highly interrelated variables are combined into one factor (Tabachnick & Fidell, 2013). Therefore, EFA can be used to reduce a scale's items into a smaller, more manageable number of factors (Hair, 2014; Tabachnick & Fidell, 2013; Velicer & Jackson, 1990).

Performing EFA

The process of performing EFA involved four main steps: assessment of (1) assumptions of EFA; (2) factorability of the data for EFA; (3) factor extractions; and lastly (4) factor rotation and interpretation (Pallant, 2013).

As a first step, the data were examined to see if it fulfilled the assumptions of EFA. The assumptions include: having interval variables, having large sample size (150 or more), and absence of outliers (Pallant, 2013; Tabachnick & Fidell, 2013). Since the TPACK items were measured using a 5-point Likert scale, this instrument could be considered as having interval variables. Thus, the first assumption that the scale items being assessed must have interval variables was fulfilled. As for the second assumption, the sample size requirement was met, as the data set in the current study had 485 cases, which was considered sufficient for factor analysis. The third assumption – the absence of missing values and outliers was ascertained during the data cleaning process (see Section 3.10.1.2). Thus, the assumptions of EFA were fulfilled, indicating it suitable to perform factor analysis on the TPACK scale.

Next, a correlation matrix was drawn to determine the strength of the relationships between the scale items. The items with correlation coefficients greater than 0.3 but less than 0.9 (absence of multicollinearity) are considered appropriate for EFA (Field, 2018). The correlation matrix revealed that a large number of correlation coefficients were between 0.3 and 0.9, indicating it appropriate for EFA (See Appendix E).

Two other statistical measures that can be used to determine the factorability of scale items for EFA are the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test. The KMO test developed by Kaiser (1960) measures sampling adequacy. A value above 0.6 indicates it as appropriate for factor analysis (Kaiser, 1960; Pallant, 2013; Tabachnick & Fidell, 2013). Bartlett's test (Bartlett, 1954) is a measure of sphericity and is used to test for statistically significant differences between the observed correlation matrix and identity matrix where the indicators in the correlation matrix are uncorrelated. Bartlett's test of sphericity with a significant value less than 0.05 is considered appropriate for factor analysis. The Kaiser-Meyer-Olkin value was 0.883 (exceeded the suggested value of 0.6), and Bartlett's test was statistically significant (< 0.05), which demonstrated the factorability of the data (see Table 3.7).

Table 3.7 *KMO and Bartlett's tests for the TPACK Scale*

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.883
Bartlett's Test of Sphericity	Approx. Chi-Square	2330.365
	df	351
	Sig.	.000

Next, as the scale met the assumptions and factorability criteria for EFA, the process of factor extraction was carried out. Factor extraction helps identify the least numbers of factors (dimensions) that best explain the relationships among scale items (Pallant, 2013). A variety of methods are available to achieve this. The most common method is to use Kaiser's criterion, to observe the eigenvalues that represent the amount of variation explained by a factor (Field, 2018). Based on Kaiser (1960) rule, factors with an eigenvalue of 1.0 or more can be retained. This method, though criticised, is reported to be accurate if the item numbers are less than 30; the sample size is greater than 250, and have an average communality of 0.6 or more (Field, 2018; Pallant, 2013). The current data set met these criteria (29 scale items, 485 samples, and average communality of 0.68), indicating its suitability to proceed with factor extraction.

The process of factor extraction involves loading of the variable on factors to find the best simple factor structure solution. The ideal solution will have groups of items that have a strong loading on one factor and does not cross load to others (Brown, 2015; Pallant, 2013; Tabachnick & Fidell, 2013). Factor rotation can be orthogonal rotation and/ or Oblique rotation. With orthogonal rotation, the underlying factors can be kept independent (not correlated), while with the oblique rotation the assumption is, the underlying factors are correlated (Brown, 2015; Field, 2018; Pallant, 2013). Several techniques are available for each type of factor rotation. Orthogonal techniques include Varimax, Quartimax, & Equimax, with Varimax being the most commonly applied orthogonal rotation technique (Field, 2018; Pallant, 2013). Oblique techniques include Direct Oblimin & Promax, with Direct Oblimin applied as the most common oblique rotation technique (Pallant, 2013; Tabachnick & Fidell, 2013). The rotation type selected should be based on underlying theories and previous research on whether the factors need to be independent or correlated (Field, 2018). Orthogonal rotation techniques are applicable if the aim is to reduce scale items or group items into independent sub-scales. In contrast, oblique rotation techniques are more appropriate if aiming to obtain several theoretically meaningful dimensions (factors) (Hair, 2014). For the current study, since the scale used was an adapted version of the TPACK scale for meaningful learning by Koh et al. (2013), and the aim was to retain as many theoretical dimensions as possible. Therefore, the Direct Oblimin (oblique) rotation technique was more applicable.

Several rounds of factor rotation were performed to construct a clearer and more interpretable scale while maintaining as many factors as the original instrument. To retain an item, the criteria suggested by Stevens (2009) was adopted, which meant, items with a factor loading of more than 0.40 on its priori scale and less than 0.40 on any other scale were retained. The best output was produced with Principal Component Analysis (PCA) extraction method using Direct Oblimin Rotation. That is, except for one, the factor extraction process resulted in 6 components with eigenvalues exceeding 1 (see below for more detail on the factor extraction method and Appendix F for detailed eigenvalue table). However, all seven components were retained for further analysis as the value for the component that did not meet the cut-off criteria and was close to one (0.974).

Another very reliable technique for factor extraction is Cattell's scree test (Cattell, 1966; Field, 2018; Stevens, 2009). With the scree test, all the eigenvalues of the factors are plotted on a graph and inspected to identify the point of inflexion where the slope of the line changes significantly (Field, 2018; Pallant, 2013). All the factors that are to the left of the inflexion point can be retained as these factors explain most of the variance in the data set (Cattell, 1966; Pallant, 2013). Inspection of the scree test showed a clear break after the first, second, third, and fourth components. Although the fifth, sixth and seventh components were close together, substantial declines in the magnitude of eigenvalues were seen between these factors (see *Figure 3.2*).

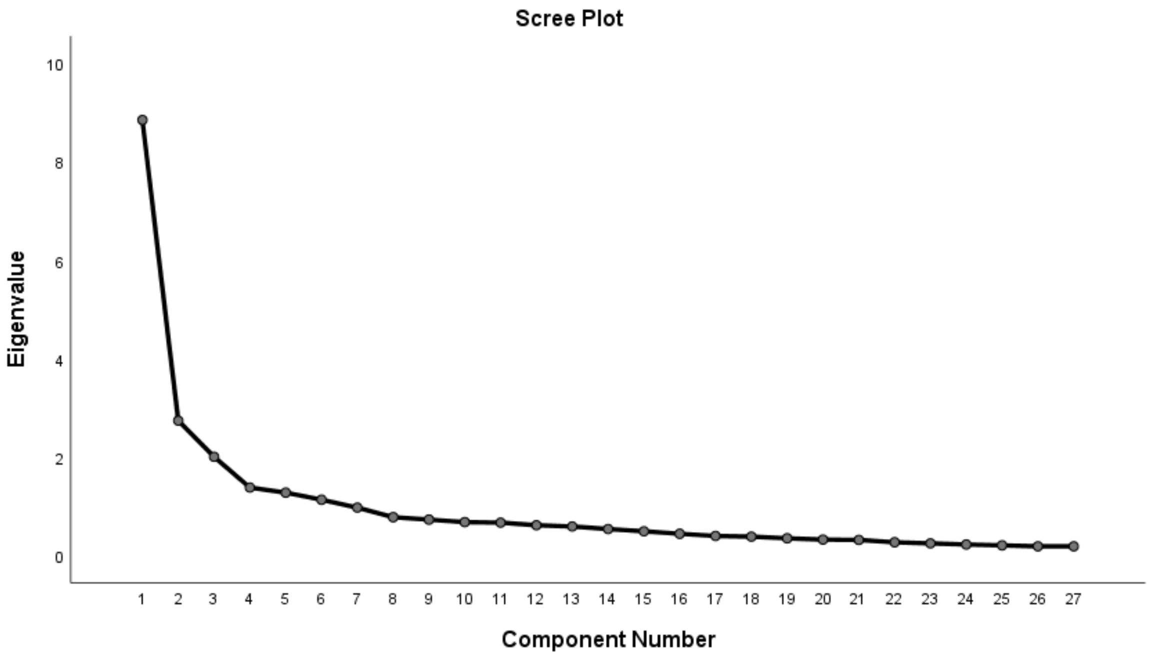


Figure 3.2 Scree plot for the TPACK scale

Further to the above two tests (Kaiser-Meyer-Olkin and Bartlett's test), Horn’s (1965) parallel analysis was carried out as an additional test to compare the observed eigenvalues extracted from the correlation matrix against a randomly generated data set having the same number of variables and sample size. Factors with observed eigenvalues greater than the corresponding values from the random data set can be retained (Pallant, 2013).

The results of Parallel Analysis indicated four components with an eigenvalue exceeding the corresponding criterion value for a randomly generated data matrix of the same sample size. The fifth, sixth, and seventh components were slightly smaller than that indicated by the parallel analysis suggesting that four constructs be retained. However, since the instrument adopted was based on an existing scale that had produced similar items and constructs, it was crucial to also consider the underlying theories and concepts (DeVellis, 2003; Henson & Roberts, 2006; O’Connor, 2000). Consequently, the seven constructs were kept tentatively for further analysis and investigation (see Appendix G for the detailed Parallel Analysis table). These seven constructs comprised the 27 items from the original scale. Two items: items labelled PCK1 (Without using technology, I can address the common misunderstandings my students have about my teaching subject) and TPK1 (I am able to use technology to introduce my students to real world scenarios) had to be removed as they were cross-loading. Nonetheless, the seven-factor solution explained a total of 68.02% of the TPACK scale variance (n=485) with thirteen iterations. Table 3.8 shows the rotated factor loadings of items with values 0.40 or greater for the TPACK scales.

To label the factors, the version of the TPACK framework by Schmidt et al. (2009) was used. The factor that clustered on component one was named “Content Knowledge (CK)” (32.78% variance) followed by “Technological Knowledge (TK)” (10.15% variance), “Technological Pedagogical Knowledge (TPK)” (7.43% variance), “Pedagogical Content Knowledge (PCK)” (5.12% variance), “Pedagogical Knowledge (PK)” (4.73% variance), “Technological Pedagogical and Content Knowledge (TPACK)” (4.2% variance) and “Technological Content Knowledge (TCK)” (3.61% variance) (see Appendix F).

Table 3.8 *Factor Loading for the Items of the TPACK Scale*

	CK	TK	TPK	PCK	PK	TPACK	TCK
	1	2	3	4	5	6	7
TK1		.753					
TK2		.682					
TK3		.770					
TK4		.728					
TK5		.604					
TK6		.574					
CK1	.687						
CK2	.748						
CK3	.673						
PK1					.666		
PK2					.849		
PK3					.876		
PK4					.740		
PK5					.777		
PCK2				.814			
PCK3				.894			
TCK1							.576
TCK2							.742
TCK3							.542
TPK2			.594				
TPK3			.818				
TPK4			.840				
TPK5			.764				
TPACK1						.596	
TPACK2						.747	
TPACK3						.617	
TPACK4						.618	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 13 iterations.
Note. Factor loadings < 0.40 are suppressed

Furthermore, the factor correlation matrix revealed that although there was a correlation among factors, (all correlations were lower than 0.7), the values were not high to cause any discriminant validity issues (Hinkle, 2003), suggesting appropriateness to perform confirmatory factor analysis (see Appendix E for the correlation matrix table)

3.10.2.2. Confirmatory Factor Analysis

In addition to EFA, the scale was also analysed using Confirmatory factor analysis (CFA). This is important; especially when using existing measures. It helps to examine the appropriateness of the measures for the population being studied and to check whether the original structure of the measure applies to the new population (Harrington, 2009). In other words, CFA can be used to confirm the factor structure identified in the EFA (Harrington, 2009). CFA and EFA are highly related in the sense that both are based on the common factor model. CFA aims to identify the underlying factors (constructs) that account for the variation among scale items (Brown, 2015; Harrington, 2009). EFA is described as more of a data-driven approach, meaning factors are derived from the study data, instead of from theory (Harrington, 2009). Whereas, CFA is considered as more theory-driven, and therefore, requires all aspects of the model to be pre-specified by the researcher before running the CFA (Harrington, 2009).

Performing CFA

Performing CFA involves several steps. Namely, (1) checking assumptions for conducting CFA; (2) specifying and creating the CFA model; (3) assessing the CFA model fit, and (4) revising the CFA model (if required).

(1) Checking assumptions

The criteria for assumptions of conducting CFA includes having adequate sample size; absence of missing data and outliers; and normality of variables (Hair, 2014; Harrington, 2009; Kline, 2016). As discussed earlier in this chapter as well in the EFA section, all the assumptions to perform CFA for the TPACK scale were met for the current study. That is, the sample size for the current study is 485 (greater than 200) which is considered “large”, and therefore acceptable for CFAs (Kline, 2016). There were no missing data or outliers identified when the data was cleaned. Therefore, since all the requirements are met, CFA was performed for the 27-item, seven-factor model (identified from the EFA performed in the previous section).

(2) Specifying and creating the CFA model

This step involves specifying and creating the CFA model. There are several software tools such as Amos, LISREL, Mplus, EQS, or SAS CALIS that can be used for this purpose. The software used to perform CFA analysis for this study was IBM SPSS AMOS v26. First, the number of latent (unobserved) variables and their correspondence with the indicator or item (observed) variables was specified (Kline, 2016). Latent variables cannot be observed, nor measured directly while indicator variables are those that can be observed (Harrington, 2009). The observed variables (based on related theory) can be used to describe how unobserved constructs should be related to each other (Harrington, 2009). Thus, the unobserved variables can be measured indirectly by linking them to those that are observed (Byrne, 2013). The observed variables are shown as rectangles and latent variables as ovals in the CFA model (Harrington, 2009). Next, the relationships among the observed and the latent variables were specified by using arrows. If the underlying construct (latent) is believed to cause the indicator (observed) variables, the arrow goes from latent to observed variables. However, if the underlying construct is a composite of several indicators, the direction of the arrow is from the observed variables to the latent variable (Hair, 2014; Kline, 2016).

Once the relationships are specified, the next step is deciding on the estimation method most applicable to test the model fit (Brown, 2015; Harrington, 2009). Estimation methods available include maximum likelihood (ML), weighted least squares (WLS), generalized least squares (GLS), and unweighted least squares (ULS). While GLS and ULS are both used with multivariate normal data (Kline, 2016), ML is the more widely used method. ML is also a better estimation procedure to use if data are multivariate normal (Harrington, 2009). The maximum likelihood (ML) estimation method was adopted to conduct CFA for the 27-item scale, seven-factor model. The objective of ML was to obtain parameter values that made the observed data most likely, or in other words, maximize the likelihood of the parameters for the data.

(3) Assessing the CFA model fit

Next, the output produced was assessed to check if the model fits the data well (Brown, 2015). This process involved two main things. *One* was to examine the parameter estimates, which include the factor loadings and unique variance (Brown, 2015; Harrington, 2009; Kline, 2016). Factor loadings show the strength of the relationship between the observed variables and their associated latent variables. To be statistically significant, the loading should be at least 0.5 or higher (Hair, 2014). The squared multiple correlations (SMC) associated with each factor loading indicates the degree of the observed variable's variance explained by the factor, while the unique variance (or measurement error) is the amount of variance in the observed variable not explained by the factors (Brown, 2015; Kline, 2016). *The second* is to examine the measures of the overall fit of the model. Measures of overall fit of the model can be tested by examining the goodness-of-fit indices. The most popularly reported goodness-of-fit indices include the Chi-square (χ^2) test, Root mean square error of approximation (RMSEA), Comparative fit index (CFI), Tucker-Lewis index (TLI), Incremental fit index (IFI), Relative fit index (RFI), and Normed fit index (NFI).

Chi-square (χ^2) test examines the model fit at an absolute level and a χ^2 value that is not significant indicates that the model fits the data (Harrington, 2009). However, this test is highly sensitive to the sample sizes; especially large sample sizes, and often produces significant χ^2 values, hence other indices are needed to check the model fit (Hair, 2014; Ho, 2006). Conversely, the RMSEA indices are relatively insensitive to the sample size and are frequently reported when evaluating the model fit for CFA (Brown, 2015; Hair, 2014; Harrington, 2009). RMSEA values less than or close to 0.05, indicates an approximate fit, values between 0.05 to 0.08 are acceptable, values between 0.08 and 0.10 are moderate and if close to 0.10 or greater, it's a poor fit (Ho, 2006; Kline, 2016). The Comparative fit index (CFI), Tucker-Lewis index (TLI), Incremental fit index (IFI), Relative fit index (RFI), and Normed fit index (NFI) are used to assess the hypothesized model against null or independence model. For these indices, values close to 0.90 or greater may indicate good fit (Brown, 2015; Kline, 2016).

The model and results of CFA output are shown in *Figure 3.3*. The model fitted the data well. The factor loadings, as shown on the arrows from the factor to the items, ranged from 0.49 to 0.85. Based on the criteria suggested by Hair (2014), all factor loadings were in the acceptable range (equal to or greater than 0.5), and all items significantly loaded.

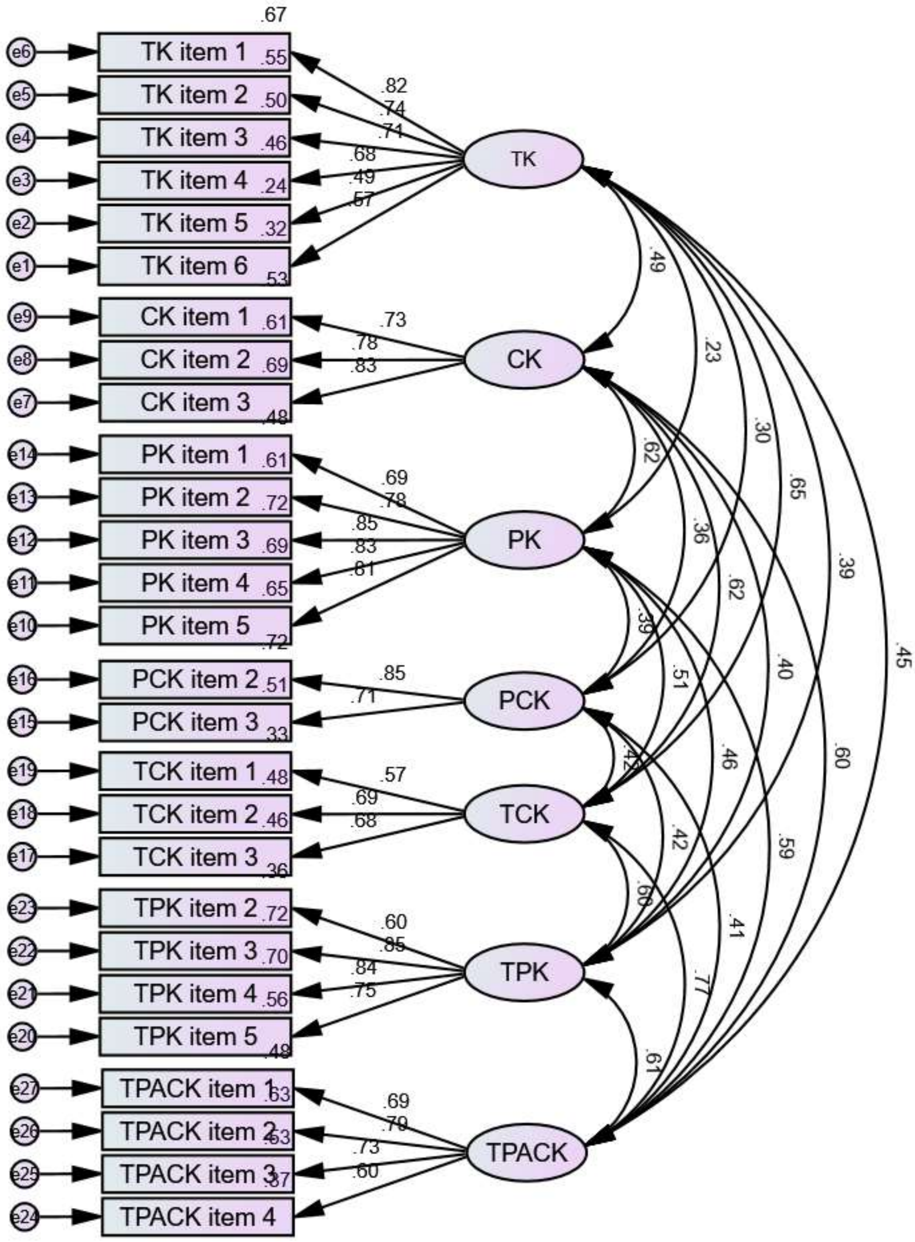


Figure 3.3 CFA model fit for 7 factors

(4) CFA model fit

Examination of the overall fit of the model using the goodness-of-fit indices revealed a Chi-square value of 424.317, significant (p=0.000), with 1.400 degrees of freedom, well below the upper threshold of 5. As mentioned earlier, the large sample size (485) might have resulted in significant Chi-square results. Hence other baseline indices were inspected. All the baseline comparison fit indices (see Appendix H) were above or close to the cut-off value (0.9), with TLI (0.934), and CFI (0.943), IFI (0.944), RFI (0.801), and NFI (0.828) (Harrington, 2009). The RMSEA was 0.048, below the cut-off (0.08), and close to the preferred value (0.05)

(Brown, 2015). Moreover, as seen from *Figure 3.3* above, all the values of the standardised regression weights (SRW) ranged between 0.49 and 0.85 (above or close to the cut-off value of 0.50) Brown (2015) and all the values of squared multiple correlations (SMC) ranged from 0.24 to 0.73. This indicated that the items were significant indicators of the corresponding constructs and the model converged.

3.10.2.3. Construct validity and reliability

It is important to further check the results of the CFA model for its construct validity and reliability. Construct validity is the degree to which a group of scale indicators correlates to the hypothetical constructs built to observe the indicators (Hair, 2014). The indicators should share a high amount of variance, suggesting they should converge, or have convergent validity. Evidence of high convergent validity can be observed from the factor loadings in the CFA that are statistically significant (at least 0.5 or higher) (Hair, 2014). As seen in *Figure 3.3* above, all the standardised factor loadings ranged from 0.49 to 0.85, above the guideline value (at least 0.5 or higher) suggested by Hair (2014), giving evidence for high convergent validity.

Alternatively, convergent validity can be assessed by observing the estimates of Average Variance Extracted (AVE). This is the mean variance extracted for the loading of the scale items on a factor. It is suggested that the AVE value should be 0.5 or higher to be an acceptable convergence (Hair, 2014). The AVE value calculated for the scale using the formula AVE = $(\sum_{i=1}^{n} L_i^2)/n$ was 0.52, (where *n* refers to the number of items and *L* refers to the standardized factor loadings), was above the acceptable value (0.5), and suggested adequate convergence (Hair, 2014).

Another indicator of convergent validity is the reliability of the measurement scale, which can also be used to assess the internal consistency of the measurement. Specific measures of reliability include SMC, construct reliability, variance extracted, and coefficient H.

The SMC represents the proportion of variance in the indicator variable explained by the factor and should be greater than 0.5. However, an SMC greater than 0.3 is still considered acceptable as a good mapping to the indicator (Jöreskog & Sörbom, 1989). The SMC for the current measurement ranged between 0.32 and 0.73, except for one (0.24), indicating an acceptable factor.

The construct reliability, computed using the formula CR=$(\sum_{i=1}^{n} L_i)^2/(\sum_{i=1}^{n} L_i)^2 + (\sum_{i=1}^{n} e_i)$ (where L is the standardized factor loading (or the standardised regression weight of the indicator), e is the measurement error associated with the indicator, and n represents the number of indicators) for the scale was 0.93, which is higher than the suggested value of 0.70 (Hair, 2014). This evidences high construct reliability for the model and implies that the scale items are consistently measuring the same factor.

The variance extracted expresses the overall amount of variance in the indicators accounted for by the factor. As a general rule, a variance extracted that exceeds 50% indicates a good measure of reliability (Fornell & Larcker, 1981). As mentioned earlier, the variance extracted for the TPACK scale was 52%, which exceeded the recommended percent (50%), and thus, is considered good.

Coefficient H is another popular way of reporting reliability (Cudeck et al., 2001). The coefficient H value of the TPACK construct computed using the formula $Coefficient\ H = 1/((1 + 1/(\sum_{i=1}^{n} (r_i^2)/(1 - r_i^2))))$ (where n is the number of indicators; and r represents the standardised regression weight of the indicator) was 0.97, which indicated high reliability.

Also, the internal consistency of the subscales calculated using Cronbach's alpha was moderate to high. The alpha reliability coefficients for the subscales TK, CK, PK, PCK, TCK, TPK, and TPACK are shown in Table 3.9.

Table 3.9 *Alpha reliability coefficients for the TPACK subscales*

	TK	CK	PK	PCK	TCK	TPK	TPACK	TPACK Overall
N of Items	6	3	5	2	3	4	4	27
Cronbach's Alpha	0.82	0.83	0.88	0.81	0.72	0.87	0.84	0.93

In addition, the Spearman-Brown Coefficient as proposed by Eisinga et al. (2013) was used as a further verification to calculate the reliability for PCK as it had only two items, which yielded a reliability score of 0.814. Thus, given that the reliability coefficient for all factors was above 0.70, these were considered to be highly satisfactory (Pallant, 2013). Further, the reliability for the full 27-item scale was 0.93, indicating excellent internal consistency for the scale (George, 2003). However, the readers are cautioned when interpreting the PCK results as the factor analysis for this construct resulted in only two items (one item from the original three-item scale had to be dropped as it did not yield the minimum factor loading criteria of 0.4).

Thus, having good-sized factor loadings, sufficient value of AVE, a high value of construct reliability and internal consistency, as well as a coefficient H value all suggested that the TPACK scale was reliable and valid with the sample of 485 teachers in Maldivian secondary schools.

3.10.3. Descriptive and inferential analysis

Descriptive statistics in the form of frequencies, percentages, mean and standard deviations were used to describe the Maldivian in-service teachers' familiarity and use of digital technologies (see Section 4.2), and their perception of the constructs of TPACK (see Section 4.3). Following this, inferential analysis was carried out to identify teachers' TPACK perception differences based on their demographic characteristics (see Section 4.4). Table 3.10 below shows the types of quantitative analysis performed.

Table 3.10 *Quantitative data analysis methods*

Research question 1		Variables	Method of analysis
Part 1 -	What is the perception of Maldivian in-service teachers on the constructs of TPACK?	TK, CK, PK, TPK, TCK, PCK, TPACK	Descriptive analysis Frequencies, Percentages, Means, Standard deviations
Part-2	Do teachers' perceptions of the constructs of TPACK differ based on their demographic characteristics?	*Independent* Gender, Age, Years of teaching experience, Nationality, Subject discipline, and Frequency of using technology *Dependent* TK, CK, PK, TPK, TCK, PCK, TPACK	Multivariate analysis of variance (MANOVA)

3.10.3.1. Descriptive analysis

Simple descriptive analysis in the form of frequencies and percentages was used to report teachers familiarity and use of technology in teaching and learning, while the mean scores, the standard deviation was used to analyse and report the results for the research question “what are Maldivian in-service teachers’ perception of the constructs of TPACK” (see Sections 4.2 and 4.3). This analysis helped to get an understanding of how Maldivian in-service secondary grade teachers (grades 9 and 10) perceived on the constructs of the TPACK framework.

3.10.3.2. Multivariate analysis

The one-way Multivariate Analysis of Variance (MANOVA) was appropriated to answer part two (do teachers' TPACK perceptions differ based on their demographic characteristics). This analysis aimed to understand the differences in teachers' TPACK based on two crucial teacher characteristics (nationality and subject discipline) that could offer valuable insights to targeted PD programs for the different groups. MANOVA is an extension of ANOVA and is suitable for use when comparing more than one related dependent variable (Hair, 2014; Pallant, 2013; Tabachnick & Fidell, 2013). It compares the mean of the different groups based on the dependent variables to indicate if the differences are significant or occurred by chance (Pallant, 2013). The advantage of MANOVA is that it can reduce the inflation of Type I error that may occur due to multiple tests of (likely) correlated dependent variables (Pallant, 2013; Tabachnick & Fidell, 2013). Also, the ability to measure several dependent variables via MANOVA increases the likelihood of discovering where the actual differences are inherent (Tabachnick & Fidell, 2013). The third advantage of MANOVA is, it might reveal differences that may not be found from a series of ANOVA (Tabachnick & Fidell, 2013). Therefore, MANOVA can be more powerful for comparisons where several dependent variables are involved. However, running MANOVA is more complicated than a simple ANOVA, and there are several important assumptions the data should satisfy before MANOVA can be performed. This includes:

(1) *Sample size*: According to Tabachnick and Fidell (2013) the number of cases in every cell in MANOVA should exceed the number of dependent variables;

(2) *Univariate normality*: The absolute values of Skewness and Kurtosis must be less than 1 for the distribution to be considered approximately normal;

(3) *Linearity*: The presence of a straight-line relationship between each pair of the dependent variable and can be tested via a scatterplot matrix, and the plots;

(4) *Multicollinearity*: absence of highly correlated variables and can be tested with a simple correlation analysis (should not show any values above 0.80 for Pearson’s r) (Field, 2018; Pallant, 2013);

(5) *Multivariate outliers*: This assumption is tested by comparing the Mahalanobis distance value against a critical value, (obtained using a chi-square ($\chi2$) critical value table). Mahalanobis distance is the distance of a particular observation from the mean centre of remaining observations (Pallant, 2013; Tabachnick & Fidell, 2013). This analysis indicates

observations that have a strange pattern of scores on the dependent variables (Pallant, 2013). It involves comparing the Mahalanobis distance value against a critical value, (obtained using a chi-square ($\chi 2$) critical value table). If the critical value is lower than the Mahalanobis distance score, it is considered an outlier. According to Tabachnick and Fidell (2013), the Mahalanobis distance score for the regression of seven independent variables should not exceed 24.32. The initial Mahalanobis distance score for the 485 sample size data set was 65.5670, (see Appendix I) which was above the critical value (χ^2 (5) = 24.32, p = .001), indicating the presence of outlier. The examination of the Mahalanobis distance scores revealed 15 multivariate outliers with scores exceeding the critical value. After careful consideration, these 15 cases were eliminated from the data set, resulting in 470 responses available to perform the multivariate analysis; and

(6) *Homogeneity of variance-covariance matrices*: This final assumption is tested using the Box's M test (Pallant, 2013; Tabachnick & Fidell, 2013). According to Tabachnick and Fidell (2013), an alpha value above .001 for data with unequal sample sizes indicates that the covariance matrices between the groups are equal. However, Tabachnick and Fidell (2013) caution researchers when interpreting Box's M value, as it tends to be too strict when the sample size is large. The results of this assumption are reported separately for each demographic characteristic, along with the MANOVA results (see Section 4.4).

Interpreting MANOVA results

Several statistics are available to interpret the results: Wilks' Lambda, Hotelling's Trace, Pillai's Trace, Roy's Largest Root (Pallant, 2013). The most-reported statistic is Wilks' Lambda and is suitable for general use, but if the data set has issues such as small or unequal sample sizes, or violates assumptions, then Pillai's trace is more robust (Tabachnick & Fidell, 2013). Where MANOVA resulted in statistically significant results, ANOVAs were conducted as follow-up univariate analysis. Before interpreting the results of the univariate analysis, a Bonferroni adjustment must be made to the alpha value to reduce Type I error that might result from conducting a series of univariate ANOVAs (Pallant, 2013). The Bonferroni adjustments are made by dividing the initial alpha (0.05) by the number of dependent variables (7 in this case), which resulted in a new alpha (0.007). While MANOVA suggests the existence of significant differences, the effect size explains the relative magnitude of the differences between means (Pallant, 2013; Tabachnick & Fidell, 2013). Therefore, the effect sizes with means expressed in standard deviation units are reported to explain the magnitude of the differences. The effect size was calculated using the formula: d= M1-M2/$\sqrt{[(\sigma 1^2+\sigma 2^2)/2]}$. As reported by Cohen (1988), an effect size of 0.20 is small, 0.50 is medium, and 0.8 is large. In addition to statistical significance, practical significance was also examined. The results of the multivariate analysis for each demographic variable's gender, age, years of teaching experience, nationality, subject discipline, frequency of using technologies are discussed in the next chapter (see Sections 4.4.1 to 4.4.6).

PHASE 2: QUALITATIVE PHASE

Interpretive in nature, the qualitative approach seeks to understand the opinions, experiences, and feelings of individuals and describes social phenomena as they occur naturally (Cohen et al., 2007). In this study, the qualitative data revealed how teachers integrate technology in their classrooms and the perceived impact on student's cognitive engagement. It also unveiled the benefits and challenges teachers experienced in adopting digital technology in their classroom practices. This phase of the study helped address the following research questions:

- How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact students' cognitive engagement (RQ2)?
- What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching (RQ3)?

In addition, it helped triangulate the TPACK perception findings against teachers' classroom technology integration practices. The following section details the processes that were followed in this qualitative phase.

3.11 QUALITATIVE DATA COLLECTION

The primary data collection methods for this phase were semi-structured interviews and document analysis. These are some of the most frequently used and essential sources of qualitative research (Ary et al., 2010). Interviews are helpful to gain in-depth insight into people's attitudes, values, ideas, opinions, and experiences. Similarly, examining documents and other forms of communication can help elicit information on what people do as they go about their daily activities. Each of these data collection methods is detailed below.

3.11.1. Interviews

Interviewing is a commonly used data collection method in qualitative studies. It is a primary method used to access data from informants about opinions, beliefs, and feelings about situations in their own words (Ary et al., 2010; Cohen et al., 2007). Interviews offer insights that may not be possible from other forms of data collection (Ary et al., 2010). For instance, interviews can give further insight to understand the actions and choices made by a classroom teacher. Thus, interviews can allow immediate follow-up and clarification of participants' responses. According to Cohen et al. (2007), the interview may serve three purposes. First, it may be used as the principal means of gathering information to address the research objectives. Second, it may be used to derive a hypothesis or as an explanatory device to help identify variables and relationships. Third, the interview may be used in conjunction with other methods, for instance, to follow up unexpected results, validate other methods, or go deeper into respondents' motivations and their reasons for responding as they do (Cohen et al., 2007).

Additionally, Burgess's (1985) three reasons for choosing interviewing resonated with the purpose of this study. According to Burgess, interviewing enables a researcher to access participants' past events, places, and situations, and these reasons justified the need to conduct interviews in this study as the researcher sought to understand how participants' perception of the understanding of their TPACK knowledge influenced how they used technology in their teaching. Also, the researcher was interested in understanding how their integration of technology impacted their students' cognitive engagement and the factors that influenced the teachers' use of technology in teaching. Thus, interviews were crucial in this study to achieve the research aims of understanding teachers' integration of technology. Consequently, the study adopted semi-structured interviews with guiding questions and prompts to seek answers.

3.11.2. Document review

Document review refers to the use of written documents or other artefacts to understand the phenomenon under study (Ary et al., 2010; Fraenkel & Wallen, 2009). Document analysis is considered a good source of data as documents provide researchers with readymade, descriptive information mostly from stable sources and thereby help ground the study in its context (Ary et al., 2010). Document analysis can be conducted in conjunction with other forms of data in order to strengthen the findings. However, researchers are cautioned when using this technique. For instance, public documents might have bias, caused intentionally or unintentionally. Another issue is that because documents are not created for research, they may not suit the purpose of the study underway. Thus, it is crucial to establish the authenticity of documents gathered by looking into the history, its completeness, and the original purpose of the document (Ary et al., 2010).

Considering the benefits discussed above, this study employed document analysis as part of its data collection. The purpose of this data collection method was to review documents produced by teachers/students to get an insight into how teachers planned their lessons to integrate technology into their lessons. Documents such as teachers' lesson plans, notes, assessment activity sheets, work produced by students were gathered. The purpose was to identify how teachers planned to integrate technology (to enhance or transform learning) by looking at the lesson objectives in their lesson plans. This gave the researcher an insight into how the technology was used to impact student's cognitive engagement. This was also a way of corroborating the findings from the interviews.

3.12 RESEARCH SETTING AND RECRUITMENT OF PARTICIPANTS

3.12.1. Research setting

The research setting for this phase comprised three schools from different regions in the country. This included one school from the capital city (School B) and two from the local islands (School A and School C). The rationale here was to enable the researcher to understand the similarities and differences in these regions regarding the technology resources available and how teachers utilised them to maximise students' learning opportunities. The schools have been labelled with pseudonyms (School A, School B, and School C) to conceal their identity. Further details of the school contexts are provided in chapter five (see Section 5.2).

3.12.2. Participants

Participants were selected from among the respondents who completed the survey in phase one and indicated their interest in the follow-up interview. For this purpose, a question was included at the end of the online survey for participants interested in the follow-up interview to provide their contact details. Of the 485 who completed the survey, 81 respondents provided their contact details indicating their interest in the follow-up interview. According to Cohen et al. (2007), where the population is mainly homogeneous, a sample of five or six would suffice. However, if there is heterogeneity in the population, a larger sample will be required to represent the heterogeneity (Cohen et al., 2007).

Considering that the researcher was interested to identify how teachers' pedagogical practices differed based on their school location (capital city and local islands), this presented heterogeneity in terms of the characteristics inherent within each locality. Thus, for this phase, nine teacher participants were selected using purposeful sampling techniques. Purposeful sampling is often used to select representatives (cases) for an in-depth study (Merriam & Tisdell, 2015). Since a large pool of teachers showed interest, nine participants were selected from three schools in diverse locations of the country (three from the capital city, and six from the two local islands (north and south). This allowed the researcher to get in-depth understanding of the similarities and differences among teachers in their technology integration efforts based on their TPACK perception and school location.

The selected samples included four male and five female teachers. The age of the participants ranged from 28 to 51 years. Four participants had a Master's degree as their highest qualification; three had Bachelor's degree and one a postgraduate diploma (one year after a Bachelor's degree), and another had a diploma certificate. The nine participants belonged to schools in three regions of the country. Two participants were from the English and Mathematics department, while the rest included teachers who taught Physics, Business Studies, Economics, Chemistry, and Islam. Four participants taught both grades 9 and 10, with three participants teaching in grade 10 only and two participants taught to grade 9 students. Except for one, all participants in this phase have completed their teacher training before becoming a teacher. The participants' teaching experience ranged from 6 to 27 years. All participants have had some form of training to use digital technologies, and their experience in using technology in teaching ranged between 3 to 5 years. A summary table comprising the participants can be found in Appendix J.

3.13 QUALITATIVE DATA COLLECTION PROCEDURE

The contact information provided by the participants (when they submitted the online survey) was used to contact and arrange the interviews. Upon the teacher's acceptance of the request, a meeting was set with them to arrange the interview sessions. Since two schools were located in outer islands, the researcher could not travel to both locations due to cost and time limitations. Thus, face-to-face interviews were held with teachers in the northern and central regions and, telephone interviews were held with the three teachers in one of the locations (South region). Permission from the school principal was sought before the interviews were held with the participants. School management support was also sought to arrange a meeting venue in the two schools where face-to-face interviews were held.

The interviews were conducted after explaining the interview protocol and seeking consent from the participants to audio record interviews. Permission was also obtained from the participants to use their survey data, and they were assured of anonymity in reporting the data. Participants were informed that they could request to discontinue the audio recording and the interview at any time if they wanted. According to Walsham (2006), audio recording can be helpful to capture the interview narration as it frees the researcher's concentration so that researcher can be more engaged with the interviewee. It also allows the researcher to listen whenever needed (McLafferty, 2004). Furthermore, it can get direct quotes for the actual write-up when necessary (Walsham, 2006). A voice recorder purchased for the purpose was used to record the interviews. As a precautionary measure, the researcher also took some notes during the interviews in case recording equipment failed (Jacob & Furgerson, 2012).

Each interview was roughly 30 to 45 minutes. This resulted in a minimum of 4.5 to 6.75 hours of interview data from all the teachers. As discussed earlier, a weakness of qualitative interviews is researcher bias which might result from certain ways of thinking and viewing held by the researcher. Thus, open-ended and non-leading questions and paraphrasing were employed during the interviews to minimize researcher bias (Cohen et al., 2007). This way, the researcher obtained in-depth information from the participants and clarified their responses. The questions used during the interviews are attached in Appendix K. The questions were formulated prior to the interview but allowed the researcher to modify or add follow-up questions as and when necessary to further probe based on answers provided by the interviewee. Table 3.11 below shows some sample questions from the semi-structured interview and a few follow-up questions.

Table 3.11 *Sample interview questions and follow-up (added during interview)*

Sample interview question	**Follow-up question (added during interview)**
How do you and students use the available technologies to support student learning? Can you give few examples?	You can maybe talk about something that you were able to do like … since the tablet program was not implemented successfully, you could not do what you planned to do, but, even though you could not do that, you might have made use of what is available?
What factors do you believe enable you to adopt technology in your classrooms?	Do you believe it is more effective? Why/how is it more effective?

It also helped the interviewee explain in-depth about specific ways they adopted technology in teaching, challenges, or concerns they felt were important to disclose. These aspects (how technology was used and how it impacted students' cognitive engagement) were further assessed through documents gathered from the participants. Teachers were requested to share document artefacts (e.g., lesson plans, lesson notes, assessment activities, student work) of at least three lessons where they had conducted activities using technology in their lessons. The aim was to understand how technology was integrated based on the SAMR level (see Section 2.5.3) and the cognitive engagement level achieved based on Bloom's Digital Taxonomy (see Section 2.5.2). This was to cross-validate data obtained from the interviews and add depth and richness to the findings (Tellis, 1997). Table 3.12 shows a summary of the documents that were shared by the participants.

Table 3.12 *Document artefacts shared by participants*

Participant	Lesson plan	Lesson note	Student work	Assessment
Anil	✔	✔	✕	✔
Suma	✔	✕	✕	✔
Fariyal	✔	✔	✕	✕
Ameen	✔	✔	✔	✔
Lirgam	✕	✕	✕	✕
Malik	✕	✕	✕	✕
Shidhatha	✕	✕	✕	✕
Aanisa	✕	✕	✕	✕
Raihana	✕	✕	✕	✕

A seen from the table above, due to unforeseen reasons (COVID pandemic), the researcher could not gather sufficient document evidence from all the interview participants. Only four out of the nine teachers shared documents, and this was also limited. The lesson plans were scanned to identify and compare the lesson objectives, the technology used, and the activities conducted using the technology. These were then aligned with the activity sheets to extrapolate the level of students' cognitive engagement based on how technology was integrated within the lesson.

3.14 QUALITATIVE DATA ANALYSIS

Prior to beginning data analysis, all the interviews were transcribed verbatim. Transcribing audio-recorded data was time-consuming. The researcher spent at least four hours transcribing a one-hour interview. Thus, it took a minimum of 18 to 27 hours to transcribe all the interview data. Once transcription was complete, member checking was done to ensure the transcripts accurately represented participants' views by sharing the transcripts with them (Creswell, 2014). The aim was to improve the validity of the data (see Section 3.15) by requesting the interviewees to verify and comment on the transcription before analysis was undertaken.

The data analysis of this phase was guided by the analytical principles of case study research proposed by Braun and Clarke (2006), which involved analysis of the data for themes or issues referred to as thematic coding. This required an inductive process whereby data was broken down into codes and categorized to seek themes and propositions to make meaning out of the data (Fraenkel & Wallen, 2009). The aim was to use these themes to address the research questions (see Table 3.13).

Table 3.13 *Qualitative data analysis methods*

Research question/sub-question	Method of analysis
1. How do Maldivian in-service teachers’ implement digital technologies in their classrooms?	Thematic analysis of Interviews Content analysis of document artefacts
2. What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?	Thematic analysis of Interview

According to Braun and Clarke (2006), the process of data analysis involves six key stages: familiarizing with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (see *Figure 3.4*). The process followed in analysing the qualitative data gathered during this phase is explained in the subsequent sections.

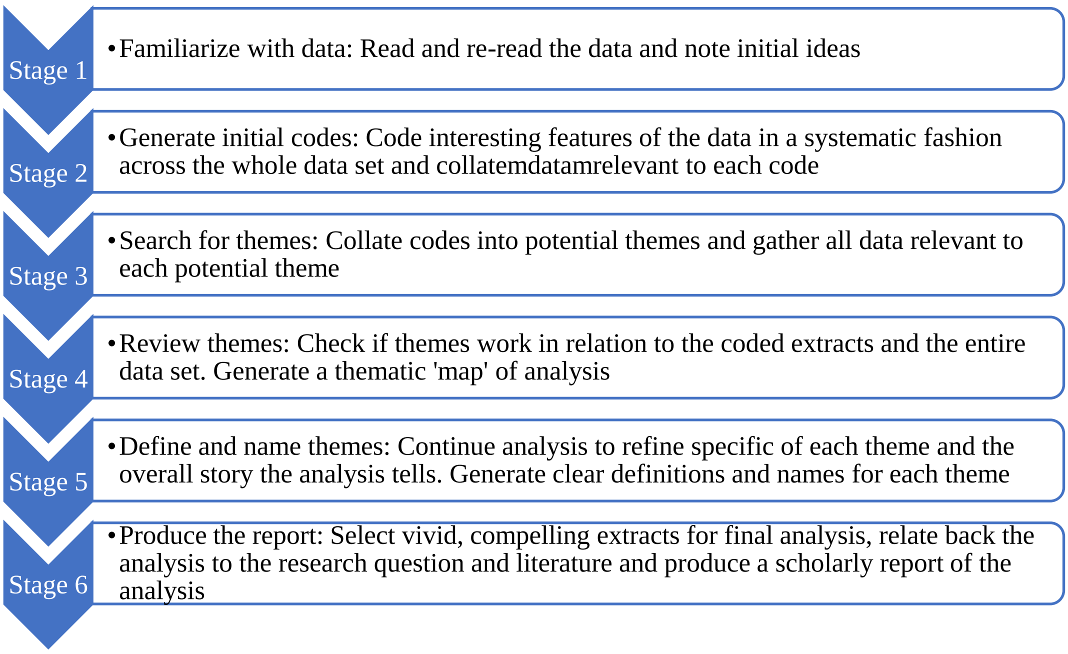


Figure 3.4 Qualitative data analysis process adapted from (Braun & Clarke, 2006)

3.14.1. Familiarize with data

Data analysis began with organizing and preparing the data for analysis. This included transcribing interviews and sorting and arranging data into different groups depending on the sources. As for documents, since the participants emailed these, they were stored electronically in the researchers' computer system in chronological order (Creswell, 2014). Next, the transcribed data and the documents were imported to NVivo for organizing and coding. Each data set (individual transcripts of each teacher and documents) was read through in its entirety to orientate the researcher.

3.14.2. Generate initial codes

At first, the transcripts were re-read and reflected on their overall meaning to look for recurring ideas or statements and obtain a general sense of the information. During this process, notes were maintained within NVivo on the general thoughts about data. Codes identified from interviews and document artefacts were organized into categories and labelled adequately to reflect the categories. Sample NVivo coding is attached in Appendix L.

3.14.3. Search for themes

The categorized codes were then used to derive themes related to how teachers integrated technology into their classrooms and the factors that influenced their technology integration efforts. The themes were derived inductively based on the research questions. Thematic analysis was used to connect and describe the relationship between the themes and convey the analysis findings (Creswell, 2013). This was done for each data set separately to ensure the themes were identified uniquely for each participant. Microsoft excel was used during this process to transfer the codes generated using NVivo to get a sense of the emerging themes. Samples of themes generated from this process are attached in Appendix M and Appendix N.

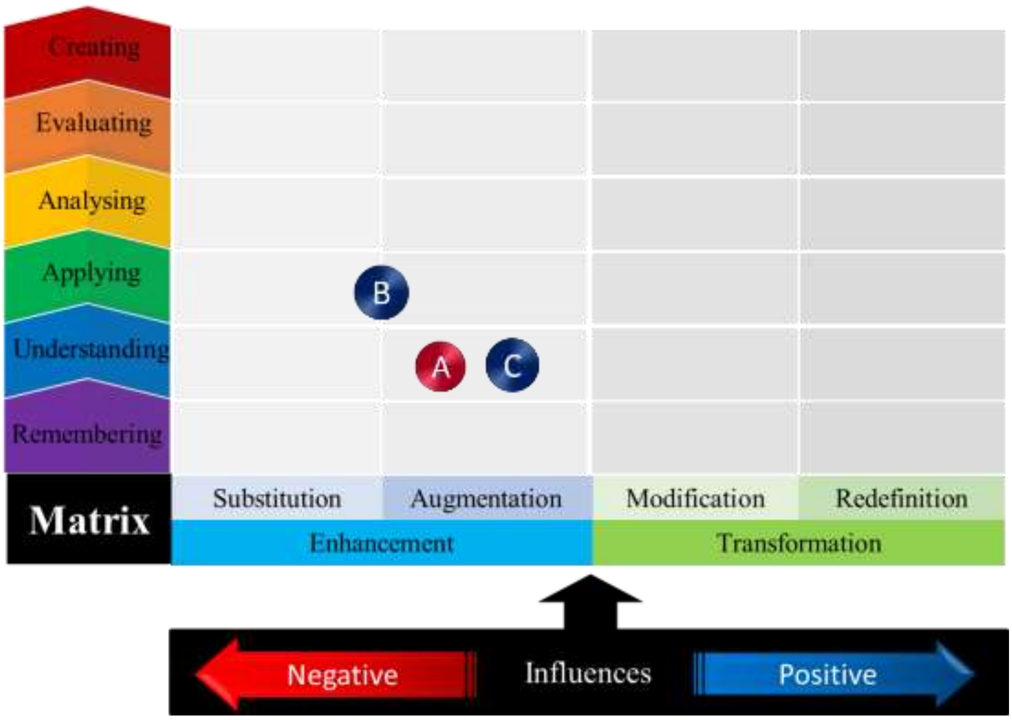
3.14.4. Review themes

The data were analysed at a higher level or axial coding during this process by completing a theoretically sensitive categorization procedure. The initial themes identified for each participant's data set were then reviewed, and related themes were combined to derive a clear set of themes. The themes were inductively derived based on teachers' responses to how they implemented technology in their classrooms (see Appendix M) and the factors that influenced their technology integration efforts (see (see Appendix N). These responses helped interpret their stories and the embedded meanings and evaluations to each teacher’s specific context

(Clandinin & Caine, 2013). The analysis was carried out by constantly comparing emerging categories to determine their nature and significance to the study's objectives.

3.14.5. Define and name themes

This step of data analysis involved making interpretations or finding meaning within the data. These were explanations based on: (1) the researcher's interpretation, (2) meaning derived from a comparison of the findings, (3) new questions that came up during the analysis procedure. At this stage, the themes were compared against the TPACK survey scores and the documents shared by participants to corroborate the evidence and validate findings (Patton, 1999). This allowed the researcher to identify how teachers used technology to facilitate their teaching in the classroom concerning their TPACK perception. The teacher responses were analysed with minimal interpretations initially (in the qualitative findings chapter). A base model with a two-dimensional matrix (see *Figure 3.5*) was developed for this analysis, as shown below.



Key: A – Showing a video (teacher)
B - Write an essay using Microsoft Word (student)
C – Doing an interactive quiz (student)

Figure 3.5 Base model: Two-dimensional matrix to represent individual teachers' implementation of technologies in their classroom and the perceived impact on student's cognitive engagement

The above model captured how teachers integrated technology in their classrooms in relation to the conceptual framework proposed in chapter two (see Section 2.7) and the themes identified from the interview data as mentioned in the previous step (see Section 3.14.4 and Appendix M). The first dimension of the matrix (row) was based on the SAMR model to assess teachers' levels of technology integration. As shown in *Figure 3.5*, technology integration can be categorized either singularly or in combination as substitution, augmentation, modification, and redefinition (Puentedura, 2012). The teacher can integrate technology to substitute an activity that can be done without technology (e.g., letter 'B' in the model – to get students to write an essay using Microsoft Word). Technology can be used to augment an activity (e.g., the letter 'A' in the model - showing a video). Using the video can enhance the explanation; the teacher can go back and forth to stress essential points. Likewise, students' learning is enhanced (e.g., letter 'C' in the model – do an interactive quiz) by allowing them to do the quiz more than once, pause and continue later, and provide instant feedback on their answers. These dimensions represent how teachers' technology integration can enhance or transform the teaching and learning processes based on the SAMR model (Puentedura, 2012).

As mentioned earlier, the data for this phase were drawn from the semi-structured interviews where teachers were asked to describe by giving example situations how they used digital technology (see Section 3.11, Section 3.14.4 and Appendix M). In addition, an assessment tool was developed to compare the degree of technology integration based on the SAMR framework by collating examples from (Puentedura, 2012) and other researchers as a guideline (see Appendix Q). This tool was then used to evaluate each teacher's response on the type of technology-based activity, who used the technology (teacher or student), and the degree of impact on teaching (SAMR).

The second dimension of the matrix (column) measures the 'cognitive learning process' based on Bloom's Digital Taxonomy (BDT) as proposed by Churches (2008). The BDT provides a context for measures of cognitive engagement, which could be articulated smoothly to learning using digital technology (Handal et al., 2014). The cognitive process dimension includes learning associated with remembering, understanding, applying, analysing, evaluating, and creating (Krathwohl, 2002; Krathwohl & Anderson, 2010). The assessment tool developed by Churches (2008) was used as a guideline to evaluate how the technology based activity impacted students based on the levels of the BDT (see Appendix R). Please refer to the theoretical framework discussed in chapter two (see Section 2.5.2 and 2.5.3) for a detailed discussion of these two models.

The letter inside the circle represents example activities conducted with technologies, and the point where the circle is placed on the matrix depicts its impact on teaching and learning based on SAMR and BDT. The two colours of the circle distinguish between teacher (red colour) or student (blue colour) centric use of technology. The key below the matrix details the activity and whether the teacher or the student carried it out.

The upward arrow below the matrix captured the factors that influenced the technology implementation endeavours. These factors contributed to teacher's decision-making process when adopting technology for classroom teaching. The conceptual model is then elaborated according to participant comments categorised into the following themes:

- implementation of technology in classroom teaching
- impact of technology use on teaching and learning
- influences that impacted teachers' technology implementation

This base model (*Figure 3.5*) was used to represent how each teacher integrated technology in their classrooms and epitomises a generalised representation of the approach taken by each teacher in their implementation of technology. The purpose was to compare this process for each teacher, which was unique to the teacher and their context.

3.14.6. Produce the report

Finally, the themes were further unpacked, compared, and contrasted based on existing theories, along with quotes from the interviewees in the discussion chapter. This process contributed to two themes related to how teachers integrated digital technologies: teachers' integration of digital technologies in teaching and learning; and technology integration impact students' cognitive engagement. In Section 6.3, triangulated data based on these two themes are presented, followed by a two-dimensional matrix depicting the triangulation of teachers' technology integration (qualitative data analysis based on SAMR) against their TPACK perception (see Table 6.3 and *Figure 6.2*).

In addition, the thematic analysis process resulted in nine sub-themes related to factors that influenced teachers' integration of digital technologies. This includes teachers' beliefs and attitudes; knowledge and competency; resources and facilities; technical difficulties and IT support; time; school leadership' culture and community support; professional development training; parental influences; and national level support (see Sections 6.4.1 to 6.4.9). A conceptual diagram of how the key factors were derived is provided in Appendix O. These factors were then categorised as micro, meso, exo, and macro contextual level factors based on Porras-Hernández and Salinas-Amescua (2013) contextual levels (see Appendix P). Next, associations among the themes were made to triangulate and discuss the findings (Yin, 2014) The teacher and the contextual level factors that resulted from the triangulation of the analysed data helped theorise the model 'Teachers Integration of Digital Technology in Teaching and Learning - (TIDTTL)', that is proposed in this study, for conducting meaningful learning using digital technologies in the context of Maldives (see Section 6.5).

3.14.7. Validity of qualitative data

Similar to quantitative studies, reliability and validity are crucial in qualitative research as well (Golafshani, 2003). Qualitative validity relates to the measures and procedures the researcher employs to ensure the accuracy of the findings. It is about the accuracy of the findings from the researcher's standpoint, the participant, or the readers (Creswell, 2014). Qualitative reliability is about the consistency maintained by the researcher across different researchers and different projects (Creswell, 2014; Gibbs, 2007). One way to enhance the validity of qualitative research is to establish research trustworthiness (Cohen et al., 2007; Fraenkel & Wallen, 2009). According to Lincoln and Guba (1985), the notion of trustworthiness is entrusted on issues of *credibility, confirmability, transferability,* and *dependability* (Cohen et al., 2007; Weber, 2004).

Credibility refers to the truthfulness of the results from the perspective of the research participants (Creswell, 2014; Fraenkel & Wallen, 2009; Trochim, 2006). To establish credibility, close involvement with the research participants, data triangulation, and member checking are key measures (Fraenkel & Wallen, 2009; Pickard, 2013). Triangulation (see Section 3.15) implies using more than one data collection method to strengthen the credibility of qualitative studies (Stake, 1995). Member-checking, or respondent validation, is a process used to establish the credibility of the results by sharing them with the participants to check for accuracy and resonance with their experiences (Baxter & Jack, 2008). In the present study, three types of research data (survey, semi-structured interviews, and document artefacts) were gathered from the participants across the two phases, which allowed for data triangulation in analysing the results. In addition, to avoid any misinterpretation of the meaning of data, the transcribed interviews were shared with participants to clarify and validate the researchers' interpretation of their responses and maintain the data's credibility (Baxter & Jack, 2008). Also, throughout the study, the researcher engaged in peer debriefing with the supervisory team to maintain credibility in the analysis and presentation of results.

Confirmability refers to the degree to which the research outcome could be confirmed by others (Trochim, 2006). If confirmability is established, the researcher or others looking into it can trace the results back to the raw data (Pickard, 2013). To enhance confirmability, Trochim (2006) suggests implementing procedures to check and recheck the data throughout the study and describe negative instances that contradict prior observations. The six phases of the thematic analysis process followed throughout the entire analytical process allowed documented checks of the data and assisted in confirmability of the reported results (Braun & Clarke, 2006).

Transferability in qualitative studies is similar to the term generalizability in quantitative studies (Trochim, 2006). It refers to the degree to which the results of a particular study can expect to be applied in a new situation or with new people (Fraenkel & Wallen, 2009). According to Marshall and Rossman (2014), transferability can be established through reference to the study's conceptual framework drawn from well-reasoned research. The conceptual framework in this study is based on a combination of concepts and models related to theories of technology integration in teaching that had provided ample research to the field over a sustained period. The researchers cited provide insight on TPACK (Koh et al., 2013; Koh et al., 2014; Mishra & Koehler, 2006; Owusu et al., 2015b; Schmidt et al., 2009), technology integration (Puentedura, 2012, 2014a; Thornton, 2017), and impact on students' cognitive engagement (Churches, 2008; Krathwohl, 2002). These theoretical underpinnings provided depth to the concepts discussed in this study and thus shaped the present study's conceptual and theoretical framework.

Dependability corresponds to reliability in quantitative studies (Lincoln & Guba, 1985). Dependability evaluates whether the research process is logical, traceable, and documented (Trochim, 2006). In other words, it checks whether the same results appear when the same thing is done twice. Often dependability is challenging to achieve within qualitative work as there can be numerous interpretations of the same data (Pickard, 2013). That is, data gathered on the same real-life situation by different researchers, using the same research methodologies, and at the same time can still be different and therefore may not collaborate into one conforming picture (Neuman, 2014).

To achieve dependability, this study adopted protocols in developing interview guides, conducting the interviews, gathering document artefacts, as well as transcribing and analysing the interview and document artefacts (Yin, 2014). This included developing an audit trial, providing a copy of the interview guide to key stakeholders (supervisor, participants), maintaining field notes during interviews, member checking with interviewees to ensure the transcripts accurately represented their views. In addition, the coded segments of transcripts and document artefacts were checked several times to revise the coding scheme accordingly. Also, an independent third party was invited to co-code a segment of the data as recommended by (Lincoln & Guba, 1985). The segments that were coded differently were discussed with the co-coder and an agreement was reached after going through all the relevant segments. The consistent analytic method of deductive and inductive thematic analysis was used in analysing data. This process was important to establish the reliability of the qualitative coding analysis. It is believed that the six-stage analytical process (Braun & Clarke, 2006) and the use of established theoretical models (SAMR framework (Puentedura, 2012), Blooms' Digital Taxonomy (Churches, 2008), and the contextual factors (Porras-Hernández & Salinas-Amescua, 2013) can be replicated in other contexts to investigate teachers' technology integration and the factors that affect efforts.

3.15 TRIANGULATION AND FINAL ANALYSIS

Triangulation is a powerful way of demonstrating concurrent validity, particularly in qualitative research by corroborating evidence from different individuals, types of data, or methods of data collection (Cohen et al., 2007). As described in Section 3.14.6 above, data from both quantitative and qualitative analysis phases were converged to address the objectives in the current study. Data triangulation strategies were adopted by comparing the findings from the participants against each other and between the data sources (survey results with interviews and document artefacts) and then cross-checking the data through follow-up interviews with participants. This was done through an embedded case study approach to identify the implications and recommendations (Eisenhardt, 1989; Yin, 2014). Data triangulation was critical and significant as it strengthened the study's trustworthiness (Onwuegbuzie & Leech, 2007). The complete research design process is depicted in the 'Research process flowchart' below (see *Figure 3.6*).

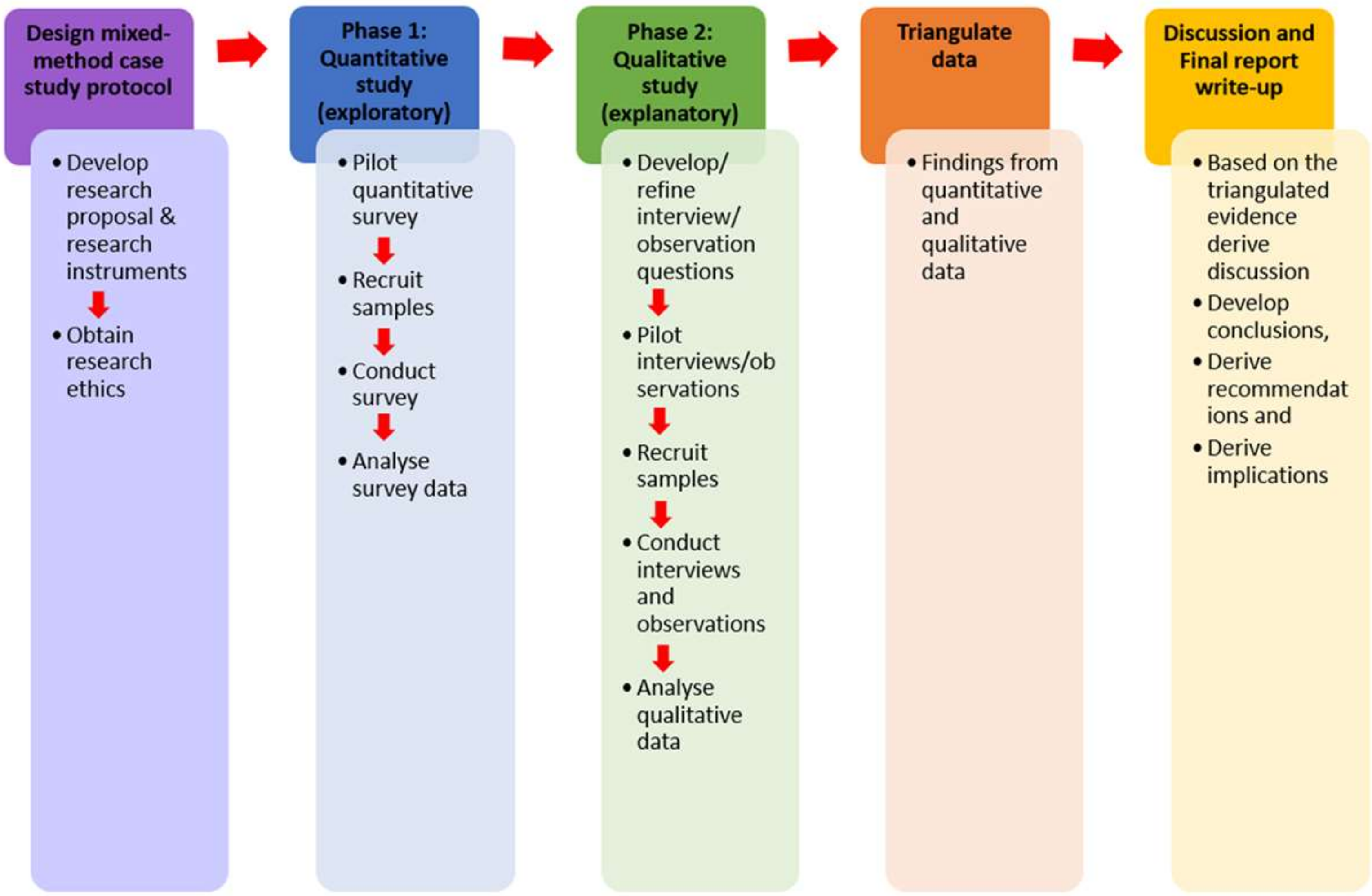


Figure 3.6 Research process flowchart

3.16 ETHICAL CONSIDERATIONS

Adhering to ethical principles is a fundamental part of any research design, regardless of the risk levels (Creswell, 2013). Thus, although the study was considered low-risk, research ethics were considered throughout the study, and before commencing data collection, ethics approval was sought from the Queensland University of Technology (Queensland University of Technology Ethics Approval Number 1900000274).

During the quantitative phase, an email with the link to the online survey was sent to the potential participants (a list of teachers teaching in grades 9 and 10 obtained from MoE). In the email, an information sheet (Appendix S) outlining the objectives of the research, the benefits and risks of participating in the research, a brief introduction of the survey (i.e., a short video on TPACK and the survey flyer attached in Appendix T), the ethical clearance letter from QUT (see Appendix U) and research permission letter from MoE (Appendix V) was shared with participants. Participants were informed that participating in the survey was voluntary, and their anonymity will be maintained. They were also informed that they could withdraw from the survey by clicking the 'leave the survey' button, but filled and submitted survey forms would be considered as consent to participate in the research (Creswell, 2013).

During phase two (qualitative interviews), before contacting participants, the researcher sought approval from the respective schools (three schools that were purposefully selected) where the teachers had volunteered (and fulfilled the criteria) to take part in this phase of the study. Participation in the follow-up interviews was also voluntary, and the participants were briefed about the research objectives, project information, and audio recording requirements before informed consent was obtained from all study participants. They were also informed of their right to withdraw from participating at any time during the study. The participants were assured of confidentiality during the research processes and final reporting. To ensure their anonymity and confidentiality, pseudonyms were used instead of real names when reporting the findings (Neuman, 2014). To safeguard the collected data, interview notes, audio recordings, and document artefacts were safely stored on the QUT network and in a back-up drive that was accessible to the researcher only.

3.17 CHAPTER SUMMARY

This chapter outlined the methodology adopted for this study. It began with the methodological framework justifying researchers' philosophical stances. The ontological and epistemological worldviews on knowledge creation were examined in order to explore the philosophical stances. These realities guided the researcher to adopt a pragmatic view to understanding teachers' technology knowledge and how they use it in their teaching.

Thus, an explanatory mixed-method case study design was believed to be suitable for addressing the research problem of understanding teachers' TPACK and technology integration, how it impacted students' cognitive engagement, and the factors that influenced teachers' efforts to adopt technology in their classrooms. Exploring these 'what', 'how', and 'why' types of research problems required the researcher to adopt different worldviews, different assumptions, as well as different forms of data collection and analysis in a single study. Hence, an explanatory mixed-method case study design was adopted to investigate the research problems in-depth using surveys, interviews, and document reviews. The chapter began by outlining the philosophical background of the research. This was followed by an introduction to the research approaches, the research design methods adopted, and justification for the choices made. As the study was carried out in two phases, the process followed in each phase, including the selection of participants, instrumentation, data collection, analysis, and triangulation, was elaborated to provide an overview of the overall research procedure followed in this study. The concept of validity, reliability for both the phases were also explained. The chapter concluded by highlighting the ethical considerations that were adhered to throughout the study.

Chapter 4: Results

4.1 INTRODUCTION

The current study investigated Maldivian in-service, lower secondary grade (grades 9 and 10) teachers' perceptions of their Technological Pedagogical Content Knowledge (TPACK), how technology was integrated into teaching and learning, the perceived impact on students' cognitive engagement, and the factors that influenced their practices. The key research questions this study aimed to explore were:

RQ1: What are Maldivian in-service teachers' perceptions of the constructs of TPACK (Technological Pedagogical and Content Knowledge)?

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

The previous chapter has provided a detailed account of the research methodology that was adopted to gather and analyse the data to address the above three research questions (see Sections 3.4 to 3.10 for more details on the procedure). The findings reported in this chapter aided in addressing the first research question (RQ1). That is, the analysis and results of the TPACK survey data collected via an online survey aided in identifying Maldivian in-service teachers' perceptions of the constructs of the TPACK (Technological Pedagogical and Content Knowledge) framework. The results of the survey data are described across the following three sections: teachers' familiarity and use of technologies (see Section 4.2); teachers' perception of their technological and pedagogical content knowledge (see Section 4.3); differences in teachers TPACK based on their demographic characteristics (see Section 4.4) and chapter summary (see Section 4.5).

4.2 TEACHERS' FAMILIARITY AND USE OF TECHNOLOGIES

Teachers who responded to this survey were asked to indicate how often they used technologies to facilitate their classroom teaching. They were given five options to choose from "I have never used technology to teach, and I don't plan to do so anytime soon", "I have never used technology to teach but I would like to learn", "I rarely use technology for instruction in the classroom - a few times a month, at most”, “I frequently use technology for instruction in the classroom - one or more times a week”, and “I always use technology for instruction in the classroom - every day or almost every day”.

Results showed that there were no teachers who "have never used technology to teach, and did not plan to do so anytime soon", while very few teachers (1.9%) indicated that although they "have never used technology to teach, would like to learn how to use it". Of the 485 respondents, 17.1 % rarely used (a few times a month, at most) technologies for instruction in their classrooms. In contrast, the majority of the participants (60.6%) in this study were frequent users (one or more times a week) of technology, with one-fifth (20.4%) of the teachers integrating technology in their classroom instructions daily. To probe this further, they were asked about their familiarity and use of some common educational technologies (Table 4.1). For each item, the responses were ranked in a Likert scale format with ‘strongly disagree’ =1; ‘disagree’ =2; ‘neither agree nor disagree’ =3’ ‘agree’ =4 and ‘strongly agree’ =5.

Table 4.1 *Teachers’ familiarity and use of technologies in their teaching*

Statements		Responses						Mean (SD)
		SD	D	N	A	SA	Total	
		Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	Freq (%)	
Presentation software. e.g., PowerPoint/ Prezi	Familiarity	1 (0.2)	5 (1.0)	2 (0.4)	146 (30.1)	331 (68.2)	485 (100)	4.7 (0.79)
	Use	1 (0.2)	12 (2.5)	85 (17.5)	217 (44.7)	170 (35.1)	485 (100)	4.1 (0.57)
Assessment software. e.g., Online quizzes/ Tests	Familiarity	8 (1.6)	29 (6.0)	64 (13.2)	214 (44.1)	170 (35.1)	485 (100)	4.0 (1.19)
	Use	58 (12.0)	75 (15.5)	162 (33.4)	124 (25.6)	66 (13.6)	485 (100)	3.1 (0.93)
Collaborative software. e.g., Wikis, Google drive, Padlet	Familiarity	7 (1.4)	32 (6.6)	54 (11.1)	228 (47.0)	164 (33.8)	485 (100)	4.1 (1.23)
	Use	59 (12.2)	68 (14.0)	134 (27.6)	149 (30.7)	75 (15.5)	485 (100)	3.2 (0.92)
Multimedia creation software. e.g., Desktop publishing, Photoshop	Familiarity	20 (4.1)	96 (19.8)	135 (27.8)	172 (35.5)	62 (12.8)	485 (100)	3.3 (1.27)
	Use	156 (32.2)	102 (21.0)	114 (23.5)	81 (16.7)	32 (6.6)	485 (100)	2.4 (1.06)
Discussion forums/boards. e.g., on Moodle, Blackboard	Familiarity	12 (2.5)	72 (14.8)	85 (17.5)	186 (38.4)	130 (26.8)	485 (100)	3.7 (1.46)
	Use	137 (28.2)	82 (16.9)	88 (18.1)	96 (19.8)	82 (16.9)	485 (100)	2.8 (1.09)
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	Familiarity	11 (2.3)	29 (6.0)	42 (8.7)	177 (36.5)	226 (46.6)	485 (100)	4.2 (1.30)
	Use	63 (13.0)	58 (12.0)	94 (19.4)	167 (34.4)	103 (21.2)	485 (100)	3.4 (0.98)
Blogging apps. e.g., Weebly, WordPress, Tumblr	Familiarity	21 (4.3)	120 (24.7)	143 (29.5)	137 (28.2)	64 (13.2)	485 (100)	3.2 (1.22)

	Use	183 (37.7)	107 (22.1)	109 (22.5)	64 (13.2)	22 (4.5)	485 (100)	2.2 (1.09)
Interactive boards. e.g., Smart board, Interactive Whiteboard (IWB)	Familiarity	11 (2.3)	64 (13.2)	81 (16.7)	173 (35.7)	156 (32.2)	485 (100)	3.8 (1.43)
	Use	105 (21.6)	84 (17.3)	87 (17.9)	119 (24.5)	90 (18.6)	485 (100)	3.0 (1.09)
Tablet or iPad-based applications	Familiarity	4 (0.8)	25 (5.2)	53 (10.9)	193 (39.8)	210 (43.3)	485 (100)	4.2 (1.25)
	Use	53 (10.9)	53 (10.9)	101 (20.8)	173 (35.7)	105 (21.6)	485 (100)	3.5 (0.89)
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	Familiarity	8 (1.6)	25 (5.2)	48 (9.9)	197 (40.6)	207 (42.7)	485 (100)	4.2 (1.32)
	Use	73 (15.1)	62 (12.8)	97 (20.0)	164 (33.8)	89 (18.4)	485 (100)	3.3 (0.92)
Virtual classrooms	Familiarity	21 (4.3)	64 (13.2)	90 (18.6)	205 (42.3)	105 (21.6)	485 (100)	3.6 (1.36)
	Use	152 (31.3)	69 (14.2)	101 (20.8)	126 (26.0)	37 (7.6)	485 (100)	2.6 (1.09)
Adaptive Learning Platforms	Familiarity	21 (4.3)	59 (12.2)	127 (26.2)	198 (40.8)	80 (16.5)	485 (100)	3.5 (1.37)
	Use	153 (31.5)	71 (14.6)	99 (20.4)	122 (25.2)	40 (8.2)	485 (100)	2.6 (1.04)

Note: The colours depict the percent or proportion of teachers that indicated familiarity and use of the digital technologies *(Green (Very highly frequent), Blue (highly frequent), Gray (frequent), Red (Least frequent))*

As shown in the above table, teachers generally indicated some familiarity with most of the technologies. The highest familiar and most frequently used technology was presentation software). This is followed by assessment software, collaborative software, web-based social media platforms, Tablet or iPad-based applications, and cloud-based applications. Although teachers seem to indicate familiarity with discussion forums, interactive boards; virtual classrooms; and adaptive learning platforms, the results showed a much lower percentage of teachers use these technologies in their teaching. The least familiar and less frequently used technologies identified by this group of teachers were multimedia creation software such as desktop publishing, photoshop, and blogging applications.

An interesting finding from the above analysis is that although the teachers indicated a high familiarity with some of the digital technologies, it did not necessarily imply that their use was also high. For example, even though teachers' familiarity with assessment software was very high, its use was much lower than some of the other technologies with a similar level of familiarity (e.g., web-based social media platforms, Tablet or iPad-based applications, Cloud-based apps). This might be the case if teachers had other factors affecting their decisions on what technology to adopt in their instruction. These findings were further explored during phase two (see chapter five).

Teachers were also asked to respond to further assistance they needed in relation to a list of common technologies (*Figure 4.1*).

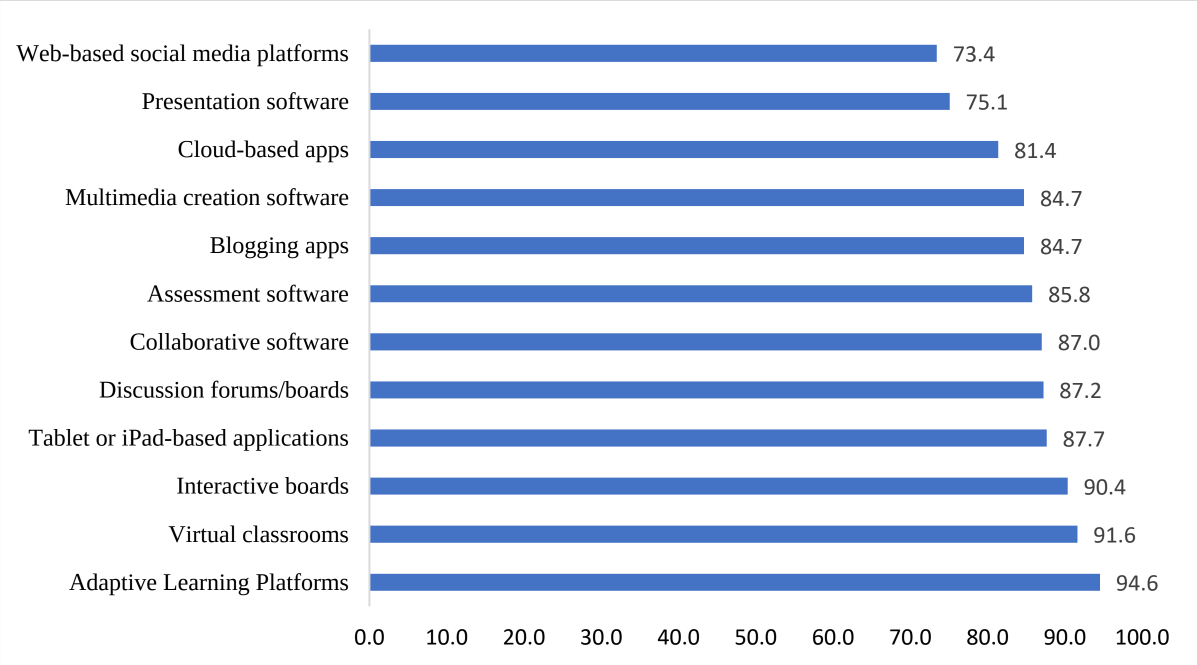


Figure 4.1 Technology assistance/ training needs of teachers

As shown in *Figure 4.1* above, teachers indicated that they required assistance/ training in almost all the technologies with the highest priority given to adaptive learning platforms, followed by virtual classrooms, interactive boards, tablet or iPad-based applications, discussion forums/boards, and collaborative software.

In sum, the above findings suggest that for the vast majority of the teachers, the most familiar (98.3%) and commonly used (79.8%) digital technologies were presentation software such as MS PowerPoint Presentation. In comparison, the least familiar (41.4%) and minimal use (17.7%) was reported for blogging applications. These findings highlight the dire need for training as more than two-thirds of the teachers report the need for training to use these technologies in their classroom teaching.

4.3 TEACHERS' PERCEPTIONS OF THEIR TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK).

The first objective of the study was to investigate Maldivian in-service lower secondary grade teachers' perception of their TPACK. Data regarding teachers' perception of their technological pedagogical and content knowledge were gathered using an adapted version of the TPACK scale by Koh et al. (2013) (refer Section 3.5 for more details on the survey instrument). The mean value for each factor of the TPACK scale was obtained to interpret teachers' perception of their TPACK. The classification proposed by Ersoy and Aktay (2007) was adopted to interpret the mean scores of the five-point Likert scale and explain the TPACK perception. According to this classification, a mean score of 1 to 1.79 was considered "very low", a score of 1.8 to 2.59 was considered "low", a score of 2.6 to 3.39 was "medium", a score of 3.4 to 4.19 was "high", and a score of 4.2 to 5" was considered "very high.

The descriptive statistics for each scale of the TPACK constructs are presented in Table 4.2 The mean scores were above 3.4 for all scales, indicating that the TPACK perception of teachers were high to very high, with the perceptions of TK, TCK, TPK, and TPACK being very close.

Table 4.2 *Teacher perception of TPACK*

	N	Minimum	Maximum	Mean	Std. Deviation
TK	485	2.00	5.00	4.11	.56
CK	485	2.67	5.00	4.65	.44
PK	485	2.80	5.00	4.52	.45
PCK	485	1.00	5.00	3.93	.89
TCK	485	2.00	5.00	4.23	.57
TPK	485	2.00	5.00	4.17	.60
TPACK	485	1.75	5.00	4.26	.55
Valid N (listwise)	485				

The figures in Table 4.2 further indicated that teachers had the highest confidence in their CK and PK. In fact, the teacher's confidence in their content and pedagogical knowledge were very high. The lowest perception was for PCK, but still is considered high based on Ersoy and Aktay's (2007) classification. A mean of 4.11 and a standard deviation of 0.56 for the technological knowledge (TK) domain indicates that, in general, teacher's confidence in their technology knowledge domain was high. The mean scores for domains TPK, TCK, and TPACK ranged between 4.17 and 4.26, suggesting their confidence in technology remained consistently high even when integrated with the other two knowledge domains.

This result shows that the sampled teachers in grades 9 and 10 are more confident with their content and pedagogical knowledge compared to the other knowledge domains. This finding is consistent with the existing literature that shows teachers associate themselves highly on their subject expertise and then on its delivery, while lower on the domains related to technology (Archambault & Crippen, 2009; Barac et al., 2017; Koh et al., 2014; Redmond & Peled, 2019). A possible reason for the high content knowledge could be that teachers in Maldivian secondary grades are required to have a specialised degree in their related subject before they can enrol for the teaching qualification. Likewise, the focus on the development of teachers' pedagogical skills during the initial teacher education program might have contributed to the high pedagogical knowledge.

Further analysis of teachers' responses to the individual items of each knowledge domain was done to identify specific areas that might be of interest and useful in targeting future professional development needs. These results are presented in the following tables (Table 4.3 to Table 4.9)

Analysis of teachers' responses to the items on the technological knowledge (TK) domain indicates that they had a high perception of the items on this domain (see Table 4.3).

Table 4.3 *Technological Knowledge*

	N	Mean	Std. Deviation
I have the technical skills to use computers effectively	485	4.39	0.63
I can learn technology easily	485	4.47	0.59
I know how to solve my own technical problems when using technology	485	3.94	0.83
I keep up with important new technologies	485	4.11	0.73
I am able to create web pages	485	3.24	1.08
I am able to use social media (e.g., Blog, Wiki, Facebook)	485	4.51	0.63

Mean score for the construct (4.11), Standard deviation (0.56)

As seen from the figures in the above table, teachers were confident with their technical skills to use computers effectively. Teachers also agreed that they can learn technology easily, keep up with important new technologies, and use social media such as Blogs, Wiki, and Facebook, in their teaching and learning. Teachers’ confidence in their ability to solve technical problems when using technology seemed slightly lower compared to the other items. However, since the mean score was 3.94, it is still considered high based on Ersoy and Aktay’s (2007) classification. Teachers ability to create web pages observed the lowest mean score of 3.24, indicating their indecisiveness or lack of confidence in creating web pages. The standard deviation for this item was 1.08; comparatively higher, indicating greater variation in teachers' responses to the item.

Teachers' highest perception was for content knowledge (CK), with an overall mean of 4.65 for the construct (see Table 4.4).

Table 4.4 *Content Knowledge*

	N	Mean	Std. Deviation
CK1 I have sufficient knowledge about my teaching subject	485	4.77	0.42
CK2 I can think about the content of my teaching subject like an expert in the subject area	485	4.55	0.58

CK3 I am able to develop in-depth understanding about the content of my teaching subject	485	4.62	0.52

Mean score for the construct (4.65), Standard deviation (0.44)

As seen from Table 4.4 above, the mean scores of individual items in this scale exceeded 4.50 suggesting that teachers perceived themselves as highly knowledgeable of their teaching subject and can think of the content of their teaching subject like a subject matter expert. It also shows that teachers' perception of their ability to develop a deeper understanding of the content of their teaching subject was very high. This finding is expected, considering the subject specialization teachers are required to have before they can enrol for the teacher education program.

Table 4.5 below shows the mean scores and standard deviation on teachers' perception of their pedagogical knowledge (PK) domain. Like CK, teachers' perception of their PK was very high, with an overall mean score of 4.52 and a very high level of agreement for all the individual items of this domain.

Table 4.5 *Pedagogical Knowledge*

	N	Mean	Std. Deviation
PK1 I am able to stretch my students' thinking by creating challenging tasks for them	485	4.48	0.55
PK2 I am able to guide my students to adopt appropriate learning strategies	485	4.52	0.55
PK3 I am able to help my students to monitor their own learning	485	4.55	0.54
PK4 I am able to help my students to reflect on their learning strategies	485	4.47	0.56
PK5 I am able to guide my students to discuss effectively during group work	485	4.57	0.55

Mean score for the construct (4.52), Standard deviation (0.45)

The high mean scores for pedagogical knowledge domain imply that teachers had a very high perception of their ability to stretch their students' thinking by creating challenging tasks for them. Also, teachers highly regarded their ability to guide students to adopt appropriate learning strategies and help students monitor their learning. Furthermore, teachers strongly perceived that they could guide students to discuss effectively during group work. The lowest item for the scale was 'helping students reflect on their learning strategies', with a mean score of 4.47 which suggests that teachers believed they can help students reflect on their learning.

Table 4.6 presents the mean scores and standard deviation on teachers' perception of pedagogical content knowledge (PCK). Among all seven TPACK constructs, the PCK produced the lowest overall mean score (3.93), and highest standard deviation (0.89).

Table 4.6 *Pedagogical Content Knowledge*

	N	Mean	Std. Deviation
Without using technology, I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject	485	3.92	.94
Without using technology, I can help my students to understand the content knowledge of my teaching subject using various teaching methods	485	3.94	.99

Mean score for the construct (3.93), Standard deviation (0.89)

The findings for this scale contradict those reported in the literature for teachers' PCK. Unlike previous studies, teachers' perception of their understanding was lowest for the items in this domain (Barac et al., 2017; Koh et al., 2014; Liu et al., 2015; Owusu et al., 2015b). It could also be related to the curriculum reform that was brought in 2014 (NIE, 2014) and the mode (didactic) of the teacher training within the Maldivian pre-service teacher training programs. Also, as stated earlier (see Section 3.10.2), having only two items from this scale (one item from the original three-item scale had to be dropped during factor analysis as it did not yield the minimum factor loading criteria of 0.4) might have affected the overall mean score for the scale.

Nonetheless, since the mean scores for the items were above 3.4, it can be deduced that there still was high confidence in teachers' pedagogical and content knowledge domain based on the classification proposed by Ersoy and Aktay (2007). These means suggest that teachers know how to select effective teaching approaches to guide student thinking and learning; and can help students understand the content of the teaching subject via various teaching methods, without the use of technology. The mean scores were high (above 3.4) suggesting high perceived confidence in their abilities to mix pedagogy and content to provide students with various methods to learn.

The mean scores for the individual items of the technological content knowledge (TCK) domain are shown in Table 4.7 below.

Table 4.7 *Technological Content Knowledge*

	N	Mean	Std. Deviation
TCK1 I can use the software that are created specifically for my teaching subject	485	4.03	0.84
TCK2 I know about technologies that I can use to research for content on my teaching subject	485	4.25	0.67
TCK3 I can use appropriate technologies (e.g., multimedia resources, simulation) to represent the content of my teaching subject	485	4.40	0.61

Mean score for the construct (4.23), Standard deviation (0.57)

An overall mean score of 4.23 was produced for the technological content knowledge (TCK), indicating high agreement amongst the teachers surveyed for this domain as well. It also suggests that teachers had high confidence in their ability to use software that are created specifically for their teaching subject. Moreover, teachers' awareness of the technologies that they can use to research for content on their teaching subject and apply them appropriately in their teaching was high.

The mean scores and standard deviation for the individual items on teachers' technological pedagogical knowledge (TPK) are shown in Table 4.8.

Table 4.8 *Technological Pedagogical Knowledge*

	N	Mean	Std. Deviation
TPK2 I am able to facilitate my students to use technology to find more information on their own	485	4.36	0.63
TPK3 I am able to facilitate my students to use technology to plan and monitor their own learning	485	4.16	0.72
TPK4 I am able to facilitate my students to use technology to construct different forms of knowledge representation	485	4.10	0.72
TPK5 I am able to facilitate my students to collaborate with each other using technology	485	4.07	0.77

Mean score for the construct (4.17), Standard deviation (0.60)

The mean scores for individual items on teachers' TPK were all above 4.0, with an overall mean score of 4.17, indicating that teachers' confidence in their ability to integrate technology into their pedagogy was high. More specifically, teachers perceived that they could use technology to introduce students to real-world scenarios. Teachers also agreed that they can facilitate students to find more information; plan and monitor their learning on their own via technology. Furthermore, teachers agreed that they can facilitate students to use technology to construct different forms of knowledge representation and collaborate with each other using technology.

Table 4.9 presents the mean scores and standard deviation for the items of the Technological Pedagogical and Content Knowledge (TPACK).

Table 4.9 *Technological Pedagogical and Content Knowledge*

	N	Mean	Std. Deviation
TPACK1 I can teach lessons that appropriately combine my subject, technologies, and teaching approaches	485	4.34	0.62
TPACK2 I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn	485	4.32	0.65
TPACK3 I can use strategies that combine content, technologies, and teaching approaches that I learnt about in my coursework in my classrooms	485	4.25	0.64
TPACK4 I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school	485	4.11	0.77

Mean score for the construct (4.26), Standard deviation (0.55)

For the technological pedagogical content knowledge, the overall mean score was 4.26, and mean scores for the individual items were above 4.0, indicating a high perception for all the items for this scale. This suggests that teachers were confident in their ability to teach lessons that appropriately combine the subject, technologies, and teaching approaches. It also indicates that teachers can select technologies for their classroom teaching to enhance what and how they teach, and what students learn. Teachers also agreed that they can use strategies that combine content, technologies, and teaching approaches that they have learnt in their coursework in their classroom. The item on teachers' leadership in helping others to coordinate the use of content, technologies, and teaching approaches at their school had a lower mean and higher standard deviation for this scale suggesting more variation in their responses. However, since the mean for the item was above 4, teachers' perceived confidence to provide leadership in helping others to coordinate the use of the content, technologies, and teaching approaches can be considered high.

Interestingly, the overall mean for the TPACK domain was 4.26; slightly higher than the other technology-related domains. This means teachers believed they can incorporate technology effectively in their teaching even though their confidence in their ability to effectively use computers or solve technical problems might be slightly lower.

In summary, the above evidence suggests that Maldivian in-service lower secondary teachers' perception of their CK and PK was very high. Likewise, a high perception was found in teachers' knowledge of the technology-related domains (TK, TPK, TCK, and TPACK) though slightly lower than their CK and PK. This implies that several in-service secondary teachers have some self-doubt with regards to their TK in applying various technologies to teach and facilitate knowledge creation of their teaching subject. Introducing technology concepts into the content and pedagogical domains seems to reduce their confidence further, as evidenced by the tendency towards lower scores to questions on the TCK, TPK, and TPACK domains (Barac et al., 2017).

4.4 DIFFERENCES IN TEACHERS TPACK BASED ON THEIR DEMOGRAPHIC CHARACTERISTICS

This section presents the results of the differences in teachers' TPACK perception based on their demographic characteristics. The aim was to better understand the key determinants of TPACK and identify areas where professional development efforts are most needed. The main demographic variables analysed include teachers' gender, age categories, years of teaching experience, nationality, teaching subject, and their experience using technology. Since this analysis involved more than one dependent variable, One-way Multivariate Analysis of Variance (MANOVA) was utilized instead of a series of One-way ANOVA to address this objective (Pallant, 2013; Tabachnick & Fidell, 2013). The preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. Except for the multivariate outliers, all the assumptions were fulfilled (see Section 3.10.3.2).

To test for multivariate outliers, the Mahalanobis distance scores were analysed and 15 cases that were found to be multivariate outliers were eliminated from the data set, resulting in 470 responses available to perform the multivariate analysis. Due to unequal sample sizes of the groups being compared, Pillai's trace criterion was used to interpret the MANOVA results for the existence of significant differences (Tabachnick & Fidell, 2013) (see Section 3.10.3.2 for how this decision made). Where MANOVA resulted in statistically significant results, ANOVAs were conducted as follow-up univariate analysis. Prior to interpreting the results of the univariate analysis, a Bonferroni adjustment was made to the alpha value to reduce Type I error that might result from conducting a series of univariate ANOVAs (Pallant, 2013) (see Section 3.10.3.2 for an explanation on how this adjustment is made).

To examine which variables significantly differed on the independent variables, post hoc analysis with Scheffe's multiple comparison procedure was used (Pallant, 2013). The following sections reports on the results of the multivariate analysis using the following headings: gender differences (Section 4.4.1); age differences (Section 4.4.2); differences with years of teaching experience (Section 4.4.3), nationality differences (Section 4.4.4), teaching subject differences (Section 4.4.5), and differences with experience of using technologies in teaching (Section 4.4.6).

4.4.1. Gender differences

The one-way MANOVA yielded a statistically significant result in terms of Pillais' Trace criterion, indicating evidence to suggest differences between males and females on the linear combination of the dependent variables $F(7, 462) = 4.12$, $p = 0.00$; Pillais' Trace = 0.059; partial eta squared = 0.059. Thus, the univariate analysis was performed with a Bonferroni adjusted alpha value of 0.007. The ANOVA results, the mean differences in the TPACK domains between males and females, and the effect sizes are presented in Table 4.10 below.

Table 4.10 *Item Mean, standard deviation, and the difference between males and females (ANOVA, and effect size) for each TPACK scale*

TPACK scales	Mean		Standard Deviation		Differences	
	Male	Female	Male	Female	F	Effect size
TK	4.22	4.03	0.51	0.53	14.68*	0.36
CK	4.69	4.62	0.41	0.44	2.64	0.15
PK	4.55	4.51	0.43	0.46	0.76	0.08
PCK	3.94	3.97	0.84	0.92	0.17	-0.04
TCK	4.29	4.21	0.53	0.53	2.32	0.14
TPK	4.22	4.21	0.57	0.56	0.05	0.02
TPACK	4.27	4.29	0.55	0.50	0.18	-0.04

N= 470 Teachers. *N*= 263 Male and 207 Female teachers.
* $p < 0.007$ (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))
Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: $d= M1-M2/\sqrt{[(\sigma1^2+\sigma2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

When the results of the dependent variables were considered separately, the only variable to reach a statistically significant difference for gender was TK, ($p<0.007$). Based on Cohen's (1988) criteria, although a statistically significant difference was seen, the effect size (0.36) is considered small. Inspection of the mean scores obtained from follow-up univariate analysis indicated that males had a slightly higher perception of TK (M = 4.22, SD = 0.51) compared to females (M = 4.03, SD = 0.53), but the actual difference in the mean scores of the two groups was small. This finding corresponded with existing literature that suggests male teachers often have higher confidence in technological knowledge compared to female teachers (Jang & Tsai, 2013; Koh et al., 2014; Lin et al., 2013; Long et al., 2020). *Figure* 4.2 below depicts in graphical form, the mean scores of the seven TPACK scales for males and females. Although not significant, it is useful to note that male teachers showed slightly higher confidence in all the other domains, except PCK, and TPACK. Interestingly PCK scale scored the lowest of the seven scales by both males and females.

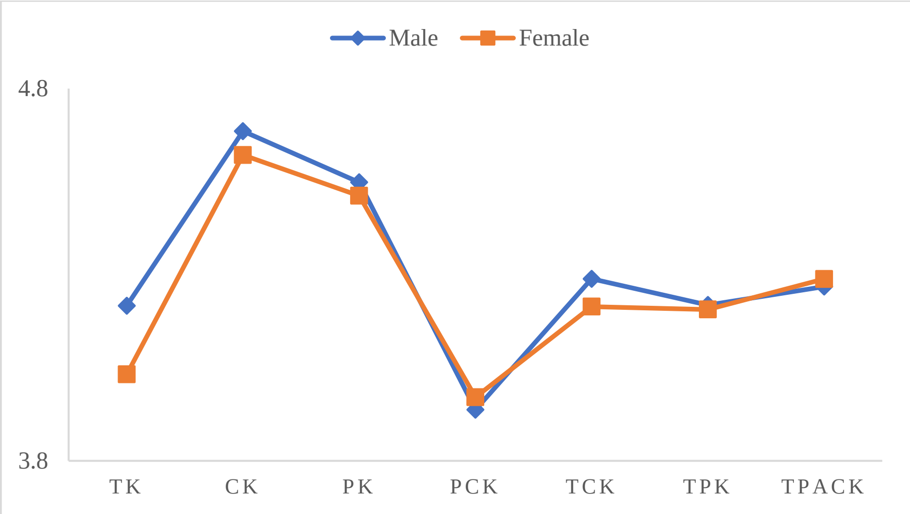


Figure 4.2 Average Item Mean for Males and Females.

4.4.2. Age differences

The data collected from teachers were used to examine whether teachers' confidence in TPACK differed for different age groups. For easier comparison, the data on teachers' age was categorised into three age groups (less than 35 years old, 35, to 44 years old, and more than 44 years). The multivariate analysis resulted in statistically significant differences for the age categories on the combined variables, F (14, 924) = 2.506, p = 0.002; Pillais' Trace = 0.073; n^2 = 0.037. The mean scores and the differences in the TPACK scales based on the age groups are shown in Table 4.11 below.

Table 4.11 *Item Mean, standard deviation, and the difference between age groups (ANOVA, and effect size) for each TPACK scale*

TPACK scales	Mean			Standard Deviation			Difference
	<35 years	35 to 44	above 44	<35 years	35 to 44	above 44	F
TK	4.12	4.16	4.12	0.54	0.54	0.49	0.327
CK	4.60	4.66	4.75	0.44	0.43	0.38	4.10*
PK	4.44	4.58	4.63	0.47	0.44	0.38	8.11*
PCK	4.01	3.97	3.82	0.78	0.92	0.97	1.67
TCK	4.22	4.31	4.24	0.54	0.53	0.50	1.35
TPK	4.15	4.27	4.24	0.57	0.57	0.53	2.31
TPACK	4.22	4.30	4.34	0.50	0.57	0.50	2.14

N= 470 teachers. N = 198 teachers less than 35 years old, 161 between 35 and 44 years old, and 111 teachers more than 44 years)
* $p < 0.007$ (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))
Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: $d= M1-M2/\sqrt{[(\sigma1^2+\sigma2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

Results of the follow-up univariate ANOVA showed statistically significant differences in CK and PK (<0.007) when compared against teachers' age groups. To interpret the statistically significant between-age group differences in scale scores identified through the ANOVAs (reported in Table 4.11 above), Post Hoc comparisons using Scheffe's multiple comparison procedure was carried out for each scale. The asterisks in Table 4.12 indicate for which scales, the pairwise comparisons of age groups were statistically significant.

Table 4.12 *Effect Size and Scheffe's Multiple Comparison for Statistical Significance of Difference Between each Pair of Ages for TPACK domains*

TPACK Scales	**Effect size and Scheffe's Multiple Comparison**		
	<35 & 35-44yrs	**35-44 & >44yrs**	**<35 & >44yrs**
TK	-0.08	0.07	-0.01
CK	-0.13	-0.22	-0.35*
PK	-0.31*	-0.13	-0.45*
PCK	0.06	0.15	0.22
TCK	-0.17	0.14	-0.04
TPK	-0.22	0.07	-0.16
TPACK	-0.15	-0.08	-0.24

Whilst there were no statistically significant differences between the two older age groups (35 to 44 years and greater than 44 years), there were statistically significant differences between the youngest and the oldest age groups in their CK (effect size of 0.35 standard deviations) and PK (effect size of 0.45 standard deviations). There was also a statistically significant difference in the PK (effect size of 0.31 standard deviations) between teachers below 35 years age group and those within the 35 to 44 years age category. However, based on Cohen's (1988) effect size criteria these differences are considered small. Comparison of the average item means for the seven knowledge scales for the three age groups are portrayed graphically in *Figure* 4.3 below.

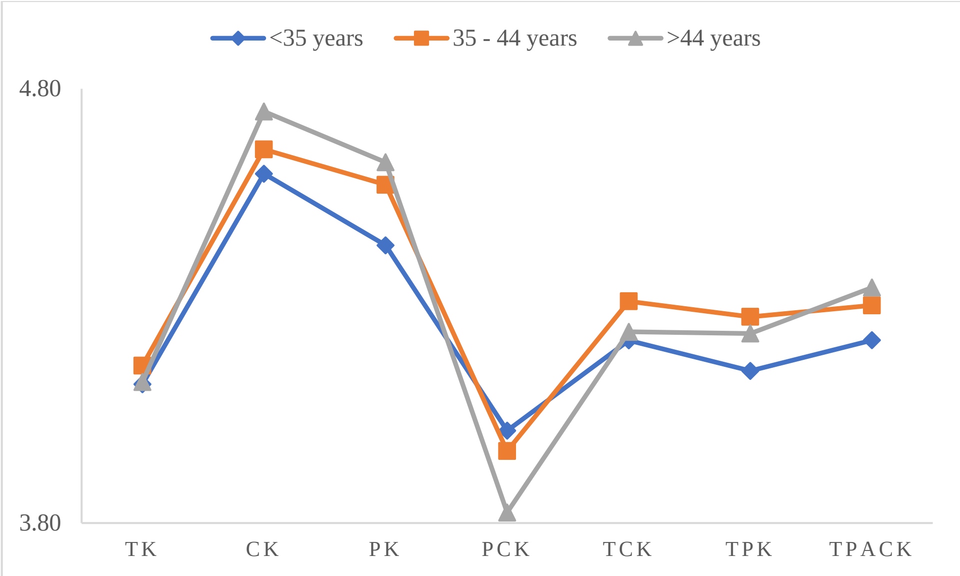


Figure 4.3 Average Item Mean for the three age categories.

Although the results were not statistically significant for all the TPACK scales, except for CK and PK, the means differences displayed in *Figure* 4.3 above, and reported in Table 4.11 earlier, indicated that teachers above 44 years of age had the highest levels of confidence in CK, PK, as well as TPACK scales. As expected, a downward trend is seen in these three scales as teachers age decreases. Interestingly teacher's confidence in TK, TCK, and TPK confidence was highest for teachers between 35 to 44 years of age. Conversely, teachers below 35 years of age seem to be the most confident group when it comes to PCK, though in general, all three age groups seem to have the lowest confidence in their PCK. Also, teachers below 35 years reported the lowest confidence in all the knowledge domains except PCK.

4.4.3. Differences with years of teaching experience

Age and teaching experience are often reported in the literature as related factors, as the majority of experienced teachers tend to be the oldest as well (Castéra et al., 2020). Empirical evidence suggests that the more experience teachers have, the lower their confidence with their TPACK (Lee & Tsai, 2010; Yaghi, 2001). If this stands true amongst the Maldivian secondary school teachers, then considerations need to be made when developing professional development avenues for teachers, especially for those who have been in the teaching service. Thus, the data gathered were investigated to find out if teachers' perception of their TPACK significantly differed based on their years of teaching experience.

For the purpose of comparison, the data on teachers’ years of teaching experience was categorised into three groups (less than 5 years, 5 to 10 years, and more than 10 years). The multivariate analysis resulted in statistically significant difference for the years of teaching experience on the combined variables, F (14, 924) = 1.847, $p = 0.029$; Pillais' Trace = 0.054; n2 = 0.029. The mean scores and the differences in the three years of experience categories for the seven scales of the TPACK are reported in Table 4.13 below.

Table 4.13 *Item Mean, standard deviation, and the difference between years of teaching experience (ANOVA, and effect size) for each TPACK scale*

TPACK Scale	Mean			Standard Deviation			Difference
	<5 years	5-10years	>10 years	<5 years	5-10years	>10 years	F
TK	4.04	4.21	4.11	0.55	0.51	0.52	3.41*
CK	4.56	4.65	4.71	0.46	0.42	0.41	3.41*
PK	4.46	4.52	4.58	0.47	0.45	0.43	0.57*
PCK	4.04	3.88	3.98	0.76	0.91	0.89	0.66
TCK	4.21	4.27	4.26	0.53	0.52	0.54	0.47
TPK	4.17	4.22	4.22	0.59	0.56	0.56	1.76
TPACK	4.16	4.30	4.31	0.56	0.49	0.54	3.41

N= 470 teachers. N= 90 < 5 years' experience, 176 between 5 to 10 years' experience, and 204 more than 10 years' experience)
* $p < 0.007$ (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))
Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: d= M1-M2/$\sqrt{[(\sigma1^2+\sigma2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

The follow-up ANOVA conducted on the TPACK subscales showed significant differences (p<0.007) in teachers' perception of TK, CK, and PK, based on their years of teaching experience. Post-Hoc comparison analysis using Scheffe's multiple comparison procedure was carried out for each scale to interpret the statistically significant between-group differences in years of teaching experience scale scores identified through the ANOVAs. Table 4.14 shows the pairwise comparisons of years of teaching experience groups. The asterisk indicates for which scales the Scheffe's procedure yielded a statistically significant result.

Table 4.14 *Effect Size and Scheffe's Multiple Comparison for Statistical Significance of Difference Between each Pair of Years of Teaching Experiences for TPACK domains*

TPACK Scales	**Effect size and Scheffe's Multiple Comparison**		
	<5 & 5-10yrs	**5-10 & >10yrs**	**<5 & >10yrs**
TK	-0.33	0.19	-0.15
CK	-0.22	-0.14	-0.35*
PK	-0.13	-0.13	-0.26
PCK	0.20	-0.12	0.07
TCK	-0.12	0.02	-0.20
TPK	-0.09	0.01	-0.09
TPACK	-0.26	-0.01	-0.26

Investigation of the effect sizes with Post Hoc analysis showed a statistically significant difference in teacher's perception for the CK only. Teachers' CK perception was statistically significant between the least and the most experienced groups (<5 & >10yrs). The effect size was 0.35 standard deviations, which, based on Cohen's criteria is considered small. Although the differences in the other six TPACK scales were not statistically significant, some important non-significant differences of interest were seen from the means produced in Table 4.13 earlier and *Figure* 4.4 below.

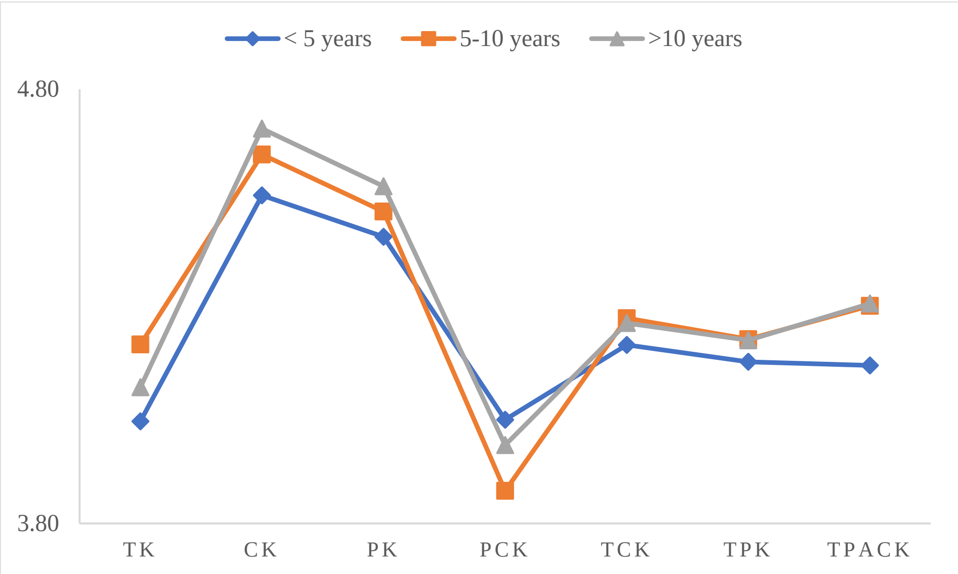


Figure 4.4 Average Item Mean for the three years of teaching experience categories.

Observation of the average item means reported in both Table 4.13 and *Figure* 4.4 shows an upward trend in teachers' confidence in CK and PK domains as their years of teaching experience increases. This is consistent with existing research that shows that the more years teachers spend teaching, the higher their confidence in content and pedagogy gets. Consequently, the highest confidence amongst all the three categories of teaching experience was also for the CK and PK domains. Beside CK and PK, teachers with more than 10 years of teaching experience also seem to be the most confident group in the TPK, and TPACK domains, while teachers with 5 to 10 years of teaching experience seem to be the most confident group when it comes to the TK, and TCK domain. All three groups of teachers seem to have the least confidence in their PCK and interestingly, the youngest group of teachers seems to be more confident in the PCK, but less confident in their TK domain compared to the other groups.

4.4.4. Nationality differences

A large proportion (63.3%) of in-service teachers in Maldivian secondary schools comprise expatriate teachers of different nationalities who are on working visas. This includes teachers from Indian and Sri Lankan nationality (see Appendix D). Thus, it was important to compare teachers' perceptions of their TPACK based on nationality, as this will help understand the professional development needs for teachers from different demographics. The nationalities that represented the survey respondents included 166 Maldivian, 299 Indians, and 5 Sri Lankans. Since the sample size for the Sri Lankan nationality was 5, this group was omitted when conducting the multivariate analysis as the small sample size for this group could distort the results. The multivariate tests results showed statistically significant differences for nationality on the combined variables, $F (7, 457) = 20.33$, $p = 0.00$; Pillais' Trace = 0.237; $n^2 = 0.237$. The difference between the two nationalities for the seven scales of the TPACK are reported in Table 4.15.

Table 4.15 *Item Mean, standard deviation, and the difference between nationalities (ANOVA, and effect size) for each TPACK scale*

TPACK scales	Mean		Standard Deviation		Difference	
	Maldivian	Indian	Maldivian	Indian	F	Effect size
TK	3.87	4.28	0.52	0.47	73.98*	-0.82
CK	4.42	4.79	0.47	0.34	92.66*	-0.90
PK	4.31	4.66	0.47	0.38	75.45*	-0.82
PCK	3.93	3.97	0.76	0.94	0.29	-0.05
TCK	4.02	4.39	0.52	0.49	57.95*	-0.73
TPK	3.94	4.37	0.54	0.52	67.77*	-0.79
TPACK	4.01	4.43	0.49	0.49	79.50*	-0.86

N= 465 Teachers. *N*= 166 Maldivian and 299 Indian teachers.
* $p < 0.007$ (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))
Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: $d= M1-M2/\sqrt{[(\sigma 1^2+\sigma 2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

There were statistically significant differences ($p < .007$) for Maldivian and Indian teachers in their TK, CK, PK, TCK, TPK, and TPACK, with Indian teachers reporting more confidence in all these domains compared to Maldivian teachers (Table 4.15). Based on Cohen's (1988) criteria, the effect sizes were medium to large for the six scales that produced statistically significant results (ranged from 0.73 to 0.90 standard deviations), reflecting the significant MANOVA results. *Figure* 4.5 below shows in graphical form, the differences in means for the seven TPACK scales based on nationality.

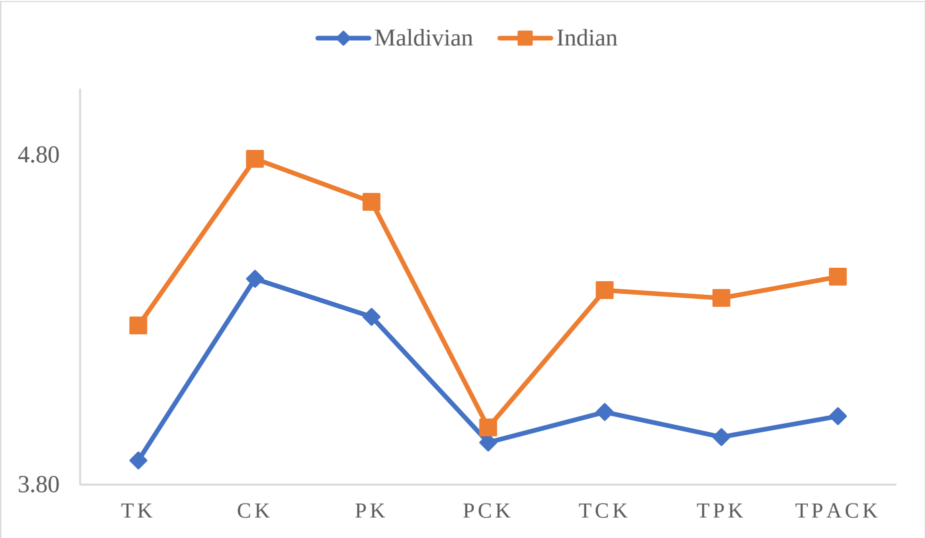


Figure 4.5 Mean scores of dependent variables against nationality.

Inspection of the mean scores in Table 4.15 and *Figure* 4.5 above indicated that teachers from Indian nationality had considerably higher confidence in all the TPACK domains. Subsequently, across the seven scales, CK recorded the highest mean for both Maldivian (mean score = 4.42) and Indian (mean score = 4.79) nationalities, followed by PK scale (mean score for Maldivians = 4.31 and Indians = 4.66). Conversely, the lowest confidence reported by Maldivian teachers was on their TK scale, while the lowest for the Indian nationality was the PCK. Teachers' confidence in TK, TCK, TPK, and TPACK scales were relatively similar and relatively high with scores of 3.87 and above for both nationalities. Likewise, the standard deviations were small for all the scales except for PCK. The greater variation in the standard deviation for PCK suggests that this is an area that teachers had some misconceptions about. The low mean for PCK also suggests the need to explore this domain on how teachers conceptualize the combination of pedagogy and content.

4.4.5. Subject discipline differences

This study also sought to identify whether teachers' confidence in their TPACK differed based on their subject specialism. In the Maldivian secondary education system, students have four compulsory subjects and four optional subjects. In this study, only the compulsory subjects (English language, Math, Dhivehi (local language), and Islamic studies) were compared as students need to pass in these subjects to succeed to the next grade level. The sample size for the four subjects comprised of 170 teachers (71 English language, 52 Mathematics, 22 Dhivehi (local language), and 25 Islamic studies) (see Appendix D). The remaining responses were excluded as the teaching subjects did not meet the selection criteria for the analysis. The multivariate tests result with Pillais' Trace showed statistically significant differences for teaching subject on the combined variables, F (21, 4867) = 2.743, p = 0.00; Pillais' Trace = 0.318; $n^2 = 0.106$. The item mean scores and the difference between the teaching subjects for the seven scales based on teaching subject are reported in Table 4.16.

Table 4.16 *Item Mean, standard deviation, and the difference between subjects (ANOVA, and effect size) for each TPACK scale*

TPACK scales	Mean				Standard Deviation				Difference
	Dhivehi	English	Math	Islam	Dhivehi	English	Math	Islam	F
TK	3.71	4.13	4.09	3.85	0.35	0.52	0.53	0.53	5.171*
CK	4.18	4.66	4.58	4.40	0.41	0.41	0.45	0.47	7.819*
PK	4.17	4.57	4.46	4.42	0.36	0.43	0.47	0.46	4.661*
PCK	3.91	3.82	4.12	4.24	0.48	0.98	0.68	0.61	2.389
TCK	3.76	4.34	4.13	3.99	0.50	0.48	0.46	0.52	9.444*
TPK	3.74	4.26	4.07	3.99	0.49	0.55	0.56	0.37	6.154*
TPACK	3.77	4.38	4.09	4.01	0.44	0.52	0.46	0.49	10.691*

N= 170 Teachers. *N*= 71 English language, 52 Mathematics, 22 Dhivehi (local language), and 25 Islamic studies teachers.
* $p < 0.007$ (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))
Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: d= $M1\text{-}M2/\sqrt{[(\sigma1^2+\sigma2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

The follow-up univariate analysis conducted on the TPACK subscales showed statistically significant results (0.007) for all the TPACK subscales, except for PCK. To identify the statistically significant between-group differences in teaching subject scale scores, Post Hoc tests were carried out with Scheffe's multiple comparison procedure. The pairwise comparisons of teaching subject groups and the effect sizes are shown in Table 4.17 below. The asterisks indicate the scales for which statistically significant differences were produced with Post Hoc tests.

Table 4.17 *Effect Size and Scheffe's Multiple Comparison for Statistical Significance of Difference Between each Pair of teaching subject groups for TPACK domains*

	Effect size and Scheffe's Multiple Comparison					
TPACK Scales	**Dhivehi & English**	**Dhivehi & Math**	**Dhivehi & Islam**	**English & Math**	**English & Islam**	**Math & Islam**
TK	-0.97*	-0.85*	-0.30	0.09	0.54	0.45
CK	-1.16*	-0.94*	-0.50	0.17	0.58	0.40
PK	-1.01*	-0.70	-0.61	0.24	0.33	0.08
PCK	0.12	-0.36	-0.61	-0.35	-0.52	-0.19
TCK	-1.19*	-0.79*	-0.45	0.43	0.70*	0.30
TPK	-1.01*	-0.63	-0.58	0.34	0.59	0.18
TPACK	-1.26*	-0.70	-0.51	0.60*	0.74*	0.16

Investigation of the effect sizes of between-subject groups in Table 4.17 above revealed statistically significant differences in all the scales, (except PCK) amongst those teaching Dhivehi and English language with large effect sizes (effect size ranged between 0.97 and 1.26 standard deviations) reflecting the significant MANOVA results. Statistically significant differences were also observed in teachers' TK, CK, and TCK between teachers teaching Dhivehi language and Math, with medium to large effect sizes (effect size ranged between 0.79 and 0.94 standard deviations). Likewise, the TPACK scale was statistically significantly different for teachers in the English language and Math department with a medium effect size of 0.60 standard deviations. There were also statistically significant differences in teachers TCK and TPACK amongst those teaching English language and Islamic studies with medium effect sizes ranging from 0.70 to 0.74 standard deviations (Cohen, 1988). The comparison of between-subject groups amongst Islamic studies teachers with Dhivehi language as well as Math teachers did not produce statistically significant differences for any of the TPACK subscales. *Figure* 4.6 below shows in graphical form, the differences in means for the seven TPACK scales based on the teaching subject.

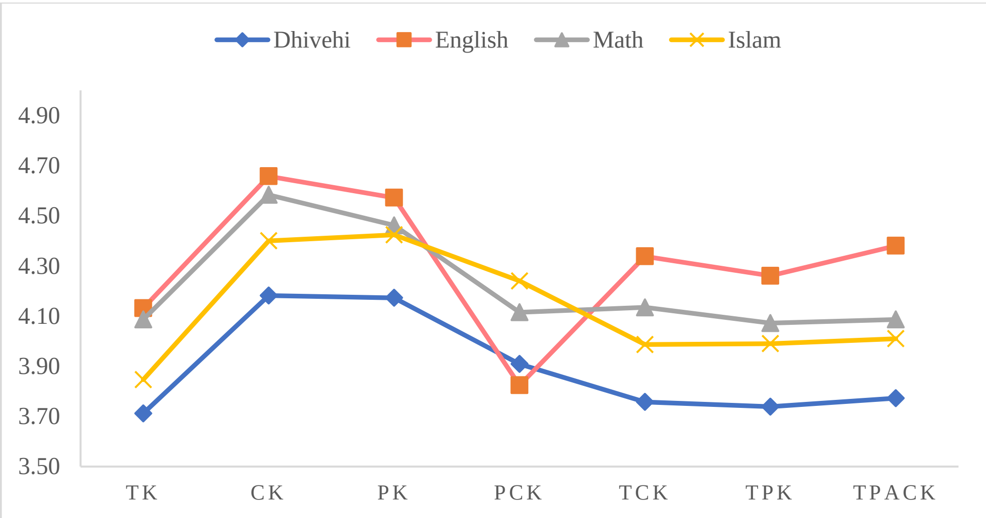


Figure 4.6 Mean scores of dependent variables against teaching subject.

The above figure above suggests English language teachers having the highest confidence in the TPACK domains followed by those teaching Math. Conversely, the lowest confidence for all the knowledge scales was seen from the teachers teaching the local language Dhivehi followed by Islamic studies. Although English language teachers reported the highest mean scores on almost all the knowledge scales, they reported the lowest mean for PCK. While teachers in the English language, Dhivehi language, and Math department reported the highest confidence in the content of their specialized subject CK, and then PK, the Islamic studies teachers reported the highest confidence in PK, and then CK. The lowest confidence reported by all the subject groups was the PCK.

4.4.6. Differences in the frequency of using technologies in teaching

The data gathered were investigated to find out if teachers' perceptions of their TPACK varied based on their frequency of using technology. During the survey, teachers were asked about their frequency of using technologies in classroom teaching, with five answer options for them to choose from. The five options were (1-I have never used technology to teach, and I don't plan to do so anytime soon, 2 - I have never used technology to teach but I would like to learn, 3 - I rarely use technology for instruction in the classroom - a few times a month, at most, 4 - I frequently use technology for instruction in the classroom - one or more times a week, and 5 - I always use technology for instruction in the classroom - every day or almost every day.). The responses for options 1 and 2 were eliminated from this analysis as the number of responses for these two groups were inadequate for the analysis and could distort the results. Thus, the remaining three groups formed the sample for this analysis. For easier representation, the groups are renamed as "Rare" (83 responses), "Frequent" (283 responses), and "Always" (96 responses).

The multivariate analysis resulted in statistically significant difference for the frequency of using technology in teaching on the combined variables, F (14, 908) = 5.929, p = 0.000; Pillais' Trace = 0.168; n^2 = 0.084. The individual item means and differences for the seven scales based on the experience in using technology in teaching are reported in Table 4.18.

Table 4.18 *Item Mean, standard deviation, and differences between frequency in using technology in teaching (ANOVA, and effect size) for each TPACK scale*

TPACK Scales	Mean			Standard Deviation			Difference
	Rare	Frequent	Always	Rare	Frequent	Always	F
TK	3.82	4.15	4.37	0.53	0.50	0.48	26.91*
CK	4.49	4.68	4.76	0.47	0.41	0.40	10.12*
PK	4.36	4.52	4.70	0.50	0.42	0.41	13.25*
PCK	4.02	3.92	3.96	0.67	0.88	1.02	0.51
TCK	3.99	4.24	4.51	0.53	0.50	0.49	24.00*
TPK	3.94	4.20	4.47	0.60	0.52	0.54	21.34*
TPACK	3.98	4.27	4.55	0.54	0.49	0.49	28.99*

N= 462 teachers. N= 83 Rare, 283 Frequent, and 96 Always
* p < 0.007 (To reduce Type I error, a Bonferroni adjustment is made to initial alpha value (0.05) by dividing it by the number of DVs (7))

Effect size is the difference in means expressed in standard deviation units and was calculated using the formula: d= M1-M2/$\sqrt{[(\sigma1^2+\sigma2^2)/2]}$. Effect size can be interpreted as small (0.2), medium (0.5), or large (0.8) (Cohen, 1988).

The follow-up ANOVA conducted on the TPACK subscales showed significant differences ($p<0.007$) in teachers' perception for all the TPACK scales except PCK, based on their frequency in using technology in teaching. To ascertain the statistically significant differences between each pair of frequencies, post-Hoc comparisons using Scheffe's multiple comparison procedure was carried out for each scale. Table 4.19 shows for which scales the pairwise comparisons of experience in using technology groups were statistically significantly different, along with the effect sizes. The effect sizes marked with asterisks indicate the statistically significant scales ($p<0.007$) with Scheffe's Post Hoc procedure.

Table 4.19 *Effect Size and Scheffe's Multiple Comparison for Statistical Significance of Difference Between each Pair of the three groups with frequency in using technology in teaching for the seven TPACK domains*

TPACK Scales	**Effect size and Scheffe's Multiple Comparison**		
	Rare & Frequent	**Rare & Always**	**Frequent & Always**
TK	-0.63*	-1.09*	-0.46*
CK	-0.44*	-0.62*	-0.19
PK	-0.35*	-0.73*	-0.42*
PCK	0.14	0.08	-0.05
TCK	-0.48*	-1.02*	-0.55*
TPK	-0.47*	-0.93*	-0.50*
TPACK	-0.57*	-1.10*	-0.56*

The Post Hoc analysis resulted in statistically significant differences in six of the seven knowledge scales (TK, CK, PK, TCK, TPK, and TPACK) between teachers that reported rare use of technology against those that always used technology in their classroom teaching. Based on Cohen's (1988) criteria, the effect sizes were medium to large (ranged between 0.62 to 1.10 standard deviations). The large effect sizes suggest greater variations between the two groups, with TK, TCK, and TPACK showing the highest differences. Likewise, Post-Hoc comparisons of teachers that reported rare use of technology against those that made frequent use of technology in their classroom teaching also produced statistically significant differences for the same six knowledge scales (TK, CK, PK, TCK, TPK, and TPACK). However, the effect sizes were not as large (ranged 0.35 to 0.63 standard deviations) indicating comparatively lower magnitudes in the differences between the two groups. Lastly, the Post Hoc comparison of teachers that were frequent users against those that always used technology in their classroom teaching resulted in statistically significant differences for five of the seven knowledge scales

(TK, PK TCK, TPK, and TPACK), with effect sizes ranging small to medium (ranged 0.42 to 0.56 standard deviations). Interestingly, PCK was not significant for any of the group comparisons. A graphical representation of the mean scores reported in Table 4.18 earlier for the seven TPACK scales based on teachers' frequency in using technology is presented in *Figure* 4.7 below.

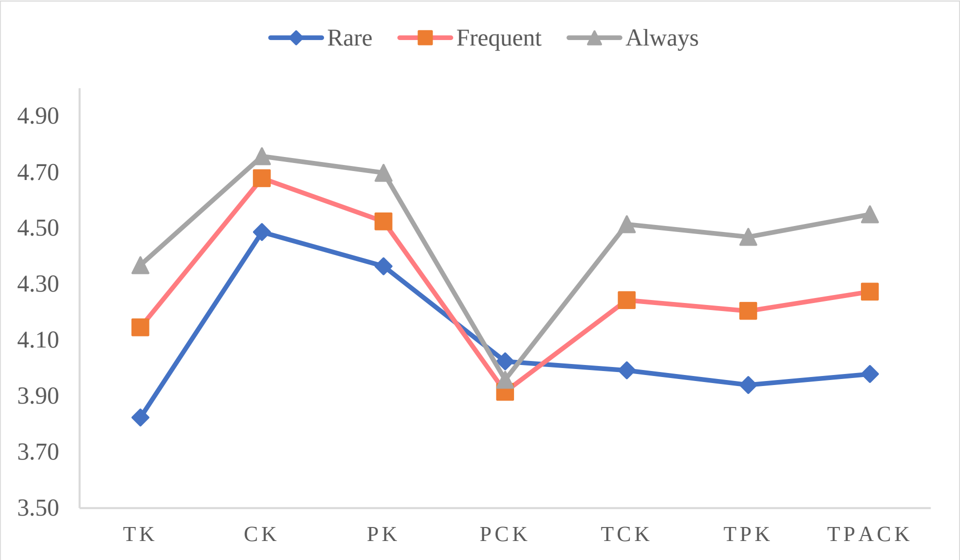


Figure 4.7 Average Item Mean for the three frequency in using technology categories.

Inspection of the item means reported in both Table 4.18 and *Figure* 4.7 above, showed a higher mean score on all the TPACK scales by teachers who always used technology in their classroom teaching, followed by those who reported frequent use of technology in their classroom teaching. The lowest mean scores for all the knowledge scales, except PCK, were for the teachers who reported rare use of technology in their classroom teaching. Teachers in the three groups were most confident with their CK, and PK domains, and least confident in their PCK. More importantly, the above graph showed marked differences in the technology-related domains amongst the three experience groups, with teachers who always used technology in their classroom teaching showing the highest confidence in all four technology-related domains.

4.5 CHAPTER SUMMARY

This chapter analysed and discussed the self-reported TPACK survey data gathered from 485 teachers teaching in grades 9 and 10 in Maldivian schools. First, a preliminary analysis was conducted to address missing values and the assumption of outliers and normality. Next, exploratory, and confirmatory factor analysis were conducted to establish the validity and reliability of the TPACK scale. Following this, teachers' experience of using technologies to facilitate their classroom teaching, their familiarity, and use of some of the most commonly available technologies were identified.

Most teachers in this study frequently used technology in their classroom teaching (at least one or more times a week). Almost all the teachers revealed that they were familiar with presentation software and used it regularly (one or more times a week) in their teaching. While many teachers seem familiar with assessment software, collaborative software, web-based social media platforms, tablet or iPad-based applications, cloud-based applications, discussion forums; interactive boards; virtual classrooms; and adaptive learning platforms, their use in teaching was much lower. Teachers were least familiar and rarely used multimedia creation software and blogging applications in their teaching. The survey results suggest that most teachers require further training in almost all the technologies, with their highest priority on adaptive learning platforms, virtual classrooms, interactive boards, tablet or iPad-based applications, discussion forums/boards, and collaborative software.

The analysis of the TPACK survey data showed how Maldivian in-service lower secondary grade teachers perceive their understanding of the various constructs of the TPACK framework. Teachers agreed with most of the items under the various constructs, which suggests that they had high confidence in their knowledge when it came to the constructs of the TPACK framework. However, the results suggest that teachers have lower confidence in their Pedagogical Content Knowledge than other TPACK constructs. This was attributed to the curriculum reform brought in 2014 (NIE, 2014) and the long tradition of the didactic nature of the teacher training within the Maldivian pre-service teacher training programs.

The findings also revealed statistically significant differences between the TPACK constructs when compared against teachers' demographic characteristics (gender, age, years of teaching experience, nationality, teaching subject, and experience of using technologies in teaching). The most significant differences (in all TPACK constructs except PCK) were observed among the nationalities, teaching subjects, and frequency of using technologies in teaching. These findings are further investigated based on the qualitative findings and backed by existing literature in the discussion chapter (see chapter six).

Chapter 5: Qualitative findings

5.1 INTRODUCTION

The current study investigated teachers TPACK and technology integration in teaching and learning in the Maldives. The purpose was to explore teachers' TPACK perception, how they integrated technology in their teaching, the perceived impact on students' cognitive engagement and the factors affecting technology integration in the teaching and learning process. For this purpose, the study applied an explanatory mixed-method design by employing quantitative questionnaires, qualitative interviews, and document artefacts from teachers teaching to lower secondary grade students (grades 9 and 10) in Maldivian public schools.

The previous chapter analysed the quantitative survey data gathered to answer RQ1: to identify teachers' perception of the constructs of the technological pedagogical and content knowledge (TPACK). This chapter reports the qualitative findings of phase two, the follow-up interviews, and document artefacts gathered from teachers and broadly addresses the second and third research questions:

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

This chapter has the following structure. The first section, Section 5.1 introduces the chapter and Section 5.2 provides a brief overview of the phase two participants' school contexts. Section 5.3 reiterates the approach taken to analyse and describe each teacher's technology integration practices. A brief profile of each teacher, an analysis of technology-based teaching and learning activities conducted, its impact on their pedagogy and student's cognitive engagement, and the factors that influenced their integration practices are analysed in Sections 5.4 to 5.12. This chapter concludes with a summary (Section 5.13).

5.2 OVERVIEW OF THE SCHOOL CONTEXTS

As explained in chapter three (see Section 3.12.2), participants for this phase were selected from the 485 teachers who completed the phase one survey. Nine participants from three schools (three teachers per school) in diverse locations of the country (North, Central, and South) were selected to enable the researcher to understand the similarities and differences in these regions regarding the technology resources available and how teachers utilised them to maximise students' learning opportunities. Pseudonyms are used to conceal the identity of the schools and the teachers. The findings begin with a short description of the school context. An analysis of how each teacher implemented technology within their classroom contexts is then described using the base model (see *Figure 3.5* in chapter three). Table 5.1 below shows the main facilities and resources available at each school.

Table 5.1 *Interview participants and their school contexts*

School	Classroom resources	Staffroom resources	Other resources
School A (Northern region) **Interview participants** Ameen, Lirgam, & Malik	No. of classrooms – 30 Desks, chairs - 25 to 30 per class Whiteboard - 1 *Smart TV (only two working) Tablet – one for each student and teacher	Desktop computers – 6 (only four systems working) Internet connection Wi-Fi access	Computer lab 15 desktop computers) Internet connection Audio-visual room Laptop – 1 Projector - 1 Internet connection Speakers - 1 Library Speakers - 1 Science laboratory Large Hall
School B (Capital city) **Interview participants** Anil, Suma, & Fariyal	No. of classrooms – 20 Desks, chairs - 25 to 30 per class Whiteboard - 1 *Projector – 1 Speakers - 1 Tablet – one for each student and teacher	Desktop computers – 6 (for 50 teachers) Internet connection Wi-Fi access Intranet	Computer lab 30 desktop computers) Projector – 1 *Smart board – 1 (Outdated) Internet connection Speakers - 1 Audio-visual room Desktop computer – 1 Projector - 1 Speakers- 1 Library Speakers- 1 Science laboratory – 2 labs Desktop computer – 1 Projector – 1 *Smart board – 1 Internet connection Speakers- 1 Printing room Desktop computer – 2 Printer – 6 Internet connection Speakers – 1 Large Hall

			Counselling room Health room
School C (Southern region) **Interview participants** Aanisa, Shidhatha, & Raihana	No. of classrooms – 25 Desks, chairs - 25 to 30 per class Whiteboard - 1 *Smart TV – 1 Speakers - 1 Tablet – one for each student and teacher	Laptop – 6 (teachers can borrow from library) Internet connection Wi-Fi access	Computer lab 20 desktop computers) Projector – 1 Internet connection Audio-visual room Desktop computer – 1 Projector – 1 Library Internet connection Science laboratory – 1 lab Internet connection Printing room Large Hall *Virtual Learning Management System (VLMS)

School A is in the country's northern region and has 603 students and 65 teaching staff. School B, with 892 students and 91 teachers, is in the central region within the country's capital city boundaries, while School C, in the southern region, had 593 students and 65 teachers (Ministry of Education, 2018). Both School A and School C having similar student numbers, accommodated students from lower kindergarten (age 4) to higher secondary grades (age 18), while School B accommodated students from grades 1 (age 6) to grade 10 (age 16). All three schools are co-educational schools funded by the government. Thus, the Ministry of Education provides the basic infrastructure, including access to the internet. However, each school’s budget was proportional to the number of students enrolled. Consequently, School B with more students had a proportionately larger budget that allowed some extra resources.

As shown in Table 5.1 above, the common facilities at each school building included the classrooms, staff rooms, laboratories, a multi-purpose hall area, administrative office areas, and an open space playground. School B had some extra facilities such as a separate printing room (to print worksheets, exam papers, etc.), a counselling and health room, and a cafeteria that offered canteen services to both students and staff.

The resources available inside the classrooms were very basic at these schools, which included desks and chairs to accommodate 25 to 30 students and the teacher and a whiteboard. The classrooms in School A and School C had a computer system connected to a Smart TV, while in School B, the system connected to a projector. The audio-visual rooms had similar resources in terms of furniture and had a projector and speaker systems to conduct activities (e.g., listening activities for English Language). The laboratories in all three schools also had projectors and additional resources such as desktop computers (in the computer lab) and scientific apparatus and chemicals (in science labs). In addition, there was an interactive board (Smart board) at the laboratories at School B. Although the laboratories mainly used subject-based practical lessons, other subject areas also used this space.

The Smart TVs and projectors at School A and C, and the Smart boards, and the projectors in School B were additional resources the schools purchased with funds acquired through parent initiatives. Unfortunately, most of the Smart TVs in both schools A and C were either damaged or outdated at the time of the study, so were the Smart boards at School B. Also, none of the classrooms at either of the schools had internet or Wi-Fi access. However, teachers had access to the internet and Wi-Fi inside the staff room and the laboratories. Teachers mainly used these facilities to prepare their lesson materials, do online training (e.g., Google classroom) and communicate with students, parents, and the school management team.

In terms of resources, there were unique differences among the three schools. For instance, School B used an intranet network service for teachers and management to exchange materials easily (e.g., lesson plans, student assessment works, etc.). Likewise, at School C, instead of desktop computers, teachers were provided laptops to borrow from the school library. While teachers mainly used laptops to prepare their lesson materials, they occasionally used them to conduct classroom activities. Perhaps one of the most significant differences between School C and the other two schools was the virtual learning management system (VLMS) used by the teachers, students, and parents. The 'Moodle' platform was used to develop the VLMS. The teachers highly regarded and appreciated this initiative.

The students and teachers of all three schools had a tablet provided by MoE as part of the digital education program (or School Digital project) in 2018. This was a Huawei brand tablet with 2GB RAM, 16 GB storage and 1280x800 resolution. The main applications installed on the tablet for teaching learning purposes include Google suite apps (e.g., Google Classroom, Google Drive, Google Meet). For security reasons, teacher and students did not have authorization to install additional apps and had to seek MoE teams support if teachers wanted to install an additional app. All the teachers at government school in the country underwent training (on Google Classroom) for the launch of this project. However, at the time the study was conducted, teachers rarely used tablets in their teaching and learning. The main reason was the lack of Wi-Fi access in the classrooms, which restricted them from conducting activities with the tablets, plus the unavailability of digital content (e.g., interactive copies of textbooks). However, to familiarise students with tablets, the school had scheduled days for when they were allowed to take their device to school to carry out learning activities.

5.3 CONCEPTUALISING TEACHERS' IMPLEMENTATION OF DIGITAL TECHNOLOGY

As explained in the methodology chapter, in order to investigate how teachers implemented technology in their classrooms and its impact on teaching and learning processes, the data were gathered in two stages: (1) semi-structured interviews; and (2) document artefacts (see Section 3.11). The interviews, together with document artefacts, provided an insight into how teachers integrated technology. It also highlighted the factors that influenced their practices associated with technology integration. The data set was analysed using Braun and Clarke's (2006) six phases of the thematic analysis process (see Section 3.14). In brief, this process involved: data familiarisation; the generation of initial themes; identification (coding) of the data sets using the initial themes; and review of themes, defining and naming themes, and producing the report. The broad themes that emerged were: (1) *teacher's implementation of technologies in their classroom teaching,* (2) *impact of technology use on teaching and learning,* and (3) *influences that impacted teachers' implementation of technologies.* These themes were in alignment with the research questions of this study (RQ2 and RQ3).

The researcher then used these themes to develop individual representations of how each teacher integrated technology in their classroom teaching. The approach adopted in this study to conceptualise how teachers implemented technology, its impact on teaching and learning, and the influences that impacted their technology integration practices was explained earlier in chapter three under Section 3.14, where the base model developed to analyse the qualitative data was presented (see *Figure 3.5*). The uniqueness inherent in each school and the teacher characteristics influenced technology integration in classrooms as explained in the following sections (Sections 5.4 to 5.12).

5.4 TEACHER 1 - AMEEN (SCHOOL A)

Ameen is a 51-year-old teacher with 27 years of teaching experience. In this regard, he can be considered as the most experienced amongst the nine participants in this study. He has been teaching Islamic Studies at the current school for the past 14 years. Ameen has a Diploma in Education qualification and indicated that he had no interest to pursue further studies. However, he embraced professional development opportunities whenever they arose. Ameen's responses to the items across the TPACK survey constructs is shown in Table 5.2 below.

Table 5.2 *TPACK survey results for Ameen*

CK	PK	PCK	TK	TCK	TPK	TPACK
5.0	5.0	5.0	4.0	3.7	4.0	4.0

The figures in Table 5.2 suggests that Ameen had 'very high' confidence in the knowledge of his subject (Islamic Studies) (CK), teaching approaches (PK), and ability to help students understand the content using various teaching methods (PCK). His confidence in technological knowledge (TK), technological pedagogical knowledge (TPK), and technological pedagogical and contents knowledge (TPACK) were 'high'. These results suggest that he was highly motivated to learn and keep up with important new technologies and solve technical problems. It also demonstrates that his confidence in combining technology for pedagogical benefits (TPK) and combining content, technology, and pedagogy (TPACK) in his classrooms was also 'high'. However, he was less confident about using software created specifically for his teaching subject (TCK). A possible reason could be the lack of content available for use with technology for his subject - Islamic Studies, which is in the local language. However, Ameen's overall TPACK perception was 'very high' (4.3).

With such high TPACK confidence, one would expect to observe a high level of technology integration in his daily teaching. The survey data indicated that Ameen’s use of technology in his classroom teaching was ‘frequent’, which meant that he used technology ‘one or more times a week’. Table 5.3 below shows a summary of his familiarity and use of some of the technologies.

Table 5.3 *Ameen’s familiarity and use of technologies*

Technologies	**Familiarity**	**Use**
Presentation software. e.g., PowerPoint/ Prezi	5	4
Assessment software. e.g., Online quizzes/ Tests	5	3
Collaborative software. e.g., Wikis, Google drive, Padlet	3	3
Multimedia creation software. e.g., Desktop publishing, Photoshop	3	2
Discussion forums/boards. e.g., on Moodle, Blackboard	4	3
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	4	3
Blogging apps. e.g., Weebly, WordPress, Tumblr	3	2
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	3
Tablet or iPad-based applications	4	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	4	3
Virtual classrooms	4	3
Adaptive Learning Platforms	4	3

According to the above table, Ameen showed ‘very high’ or ‘high’ (score of 4 or 5) familiarity with most technologies. However, the most frequently used technology for teaching purpose was ‘presentation software’ only. The interview data further explored some of these quantitative results regarding how he used these technologies in his teaching.

Implementation of technology in classroom teaching

When Ameen began his teaching career, he adopted a traditional teaching style to relay a story to students each day. To teach 'Akhlaq' (the practice of virtue, morality, and ethical conduct according to the teachings of Islam), for example, he would narrate stories from the Islamic history of how these were practised by the Prophet ﷺ and his companions and support it with 'ayah' (revelations) from the holy Quran to convey the messages contained in the Islamic

Studies textbook. Some questions followed the stories, which prompted the students to reflect and respond to what they had learnt. According to Ameen, students enjoyed these stories. However, he realised that this traditional approach was insufficient to nurture students' essential competency skills (e.g., critical and creative thinking, using technology and media) as recommended in the Maldivian National Curriculum Framework (NIE, 2014), and that more contemporary teaching methods were needed. However, Ameen claimed that he "used to be very weak when it came to computers, [and] it was something very unfamiliar, and new" to him. Thus, Ameen considered himself a late adopter of technology and only embraced it when compelled by the school principal. Ameen's late adoption of technologies aligns with Rogers's (2003) theory of 'diffusion on innovation'. Often, they are the last group to adopt, and do so out of necessity, when everyone else is already using it and may require more guidance and persuasion about the affordances of technology (e.g., by the school principal) (Rogers, 2003).

The first technology-related training he attended was a one-day course (he could not recall the exact year, but it was somewhere between 2006 and 2010), where he learned how to create lesson plans using Microsoft Word. According to Ameen, the session did not cover any aspects of using technology in teaching, nor could his colleagues help him out. A two-week "ICT skills" training programme he completed at a nearby island, which three neighbouring island schools coordinated, was a game-changer for him. This training mainly focused on developing teacher's skills to use technology in classroom teaching and covered different features of MS PowerPoint (e.g., create presentations, animations, interactive quizzes, embed videos, etc.).

Ameen found the two-week training very effective as he gained lots of new knowledge and skills on integrating technology in his lessons. Moreover, the training created opportunities for networking with other teachers who were more knowledgeable and willing to help him learn more about technology integration. He felt a sense of accomplishment, applying the knowledge he gained from the training to introduce innovations into his lessons. Though Ameen was not able to recall everything he learnt from the training, he was happy that the training helped him develop professionally and that he could convert all his lessons into PowerPoint presentations. Consequently, to keep himself updated, he stated that he continuously sought advice and assistance from his more able colleagues. Ameen's strategy here aligns with Vygotsky’s (1978) idea of the "Zone of Proximal Development" where the less able peer learns from, the more competent peer who is willing to share their knowledge or skills, a strategy that can be very useful to help support teachers embrace the technologies introduced in schools (Chandra, 2020).

Gradually, Ameen began to modify his pedagogy by leveraging digital technologies. Ameen got so enthusiastic that he created PowerPoint presentations for all the year levels he was going to teach in the following year during the school vacation. He shared his experience as follows:

> [D]uring the vacation, I decided to prepare presentations for all the lessons for all the grades 7, 8, 9 and 10 … and by luck, before I went on vacation, I knew which grades I would be teaching next year. Then I was given grades 8, 9 and 10. So all those presentations that I prepared will still be available now. Anyone who wants will always be able to get them. I give all those presentations to all the students I teach as well … (Ameen)

Ameen's keenness to use technology as evident from his quote above, was motivated by his belief that having PowerPoints would make teaching easier for him, as he would have everything prepared in advance plus, giving the presentations to student would also benefit them as they can refer to it any time to clarify doubt or even to revise. However, he was extremely disappointed that he was "unable to make use of this service [PowerPoints] the way [he] expected", due to technology failures. That is, except for the AV (audio-visual) room, and the school hall, the TVs in all the other locations (classrooms) got damaged during the academic year, and repair or replacements were not possible due to funding limitations. Thus, to use technology to conduct his lessons, he "almost begged from the management" to book the AV room or school hall, if it "ever [gets] available". So, on days when he managed to get access, he would first explain the lesson with the aid of a PowerPoint presentations, and video (if possible), followed by an assessment activity.

> I am conducting a lesson … for instance about 'Fiqh' [Islamic jurisprudence], I would first explain the key points of the lesson and show them a small video about it to students. If there are incidents from the island related to the topic, I include those in the video … I also prepare different kinds of quizzes for students to do. (Ameen)

Due to lack of internet access, he would usually save these resources in a portable USB drive (pen drive), which, when connected to the computer system, can be projected onto the Smart TV so students could see the PowerPoints and videos. He found it was easier and convenient to use technology (PowerPoints and videos), as he could repeatedly show the things he wanted to emphasise (e.g., referring to a point in the slide or recapping the learning objectives, etc.). By using videos, he would often create custom designed episodes based on incidences that occur on the island. As an example, he talked about the video he created on "an accident [that occurred] in the island" to teach students "Magumatheehe adhabuthah" (the rules to follow while on the road). He found this approach was more authentic because "students get motivated when it was on something that they have seen or experienced". He believed it also encouraged students to do the follow-up assessment activities easily.

The assessment task associated with this activity mostly involved students answering questions individually or in groups and would sometimes require them to research collaboratively and present their work. *Figure 5.1* below shows a sample group activity he assigned to students.

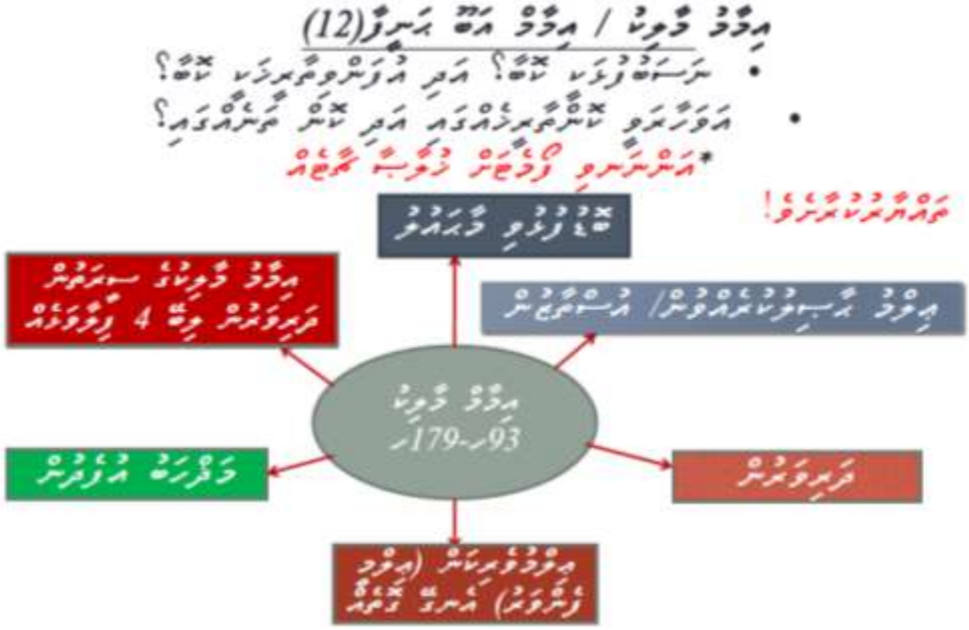


Figure 5.1 Example of a collaborative research activity "The jurisprudential four sects in Islam - Imaam Malik, Imaam Hanafee").

In the example activity above, students were required to work collaboratively to research and create a profile including the contributions made by any two leaders of the four jurisprudential sects in Islam. *Figure 5.2* below shows a part of the group work students did as a PowerPoint presentation.

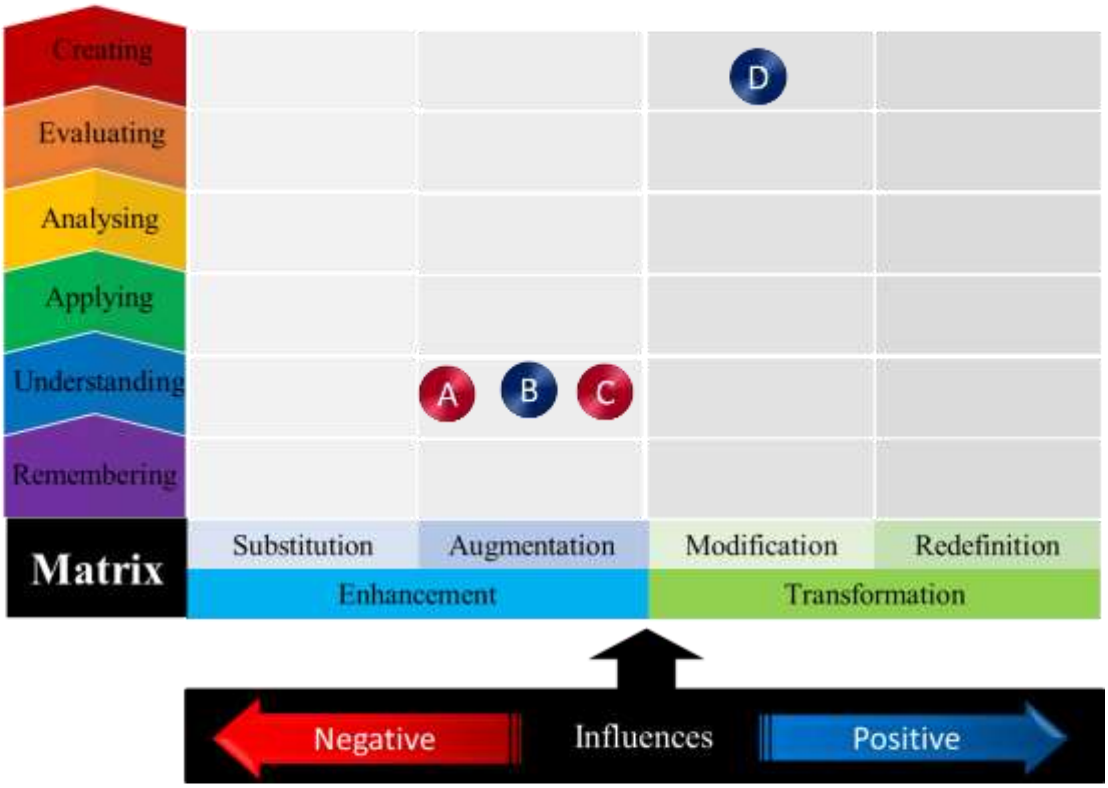
Figure 5.2 Example of students' work (PowerPoint presentation on the "Jurisprudential four sects and their leaders")

In this type of group activities, Ameen ensured participation by assigning roles with the expectation that each participant would also explain their contributions. Ameen believed that students' use of technology to actively research and create their artefacts (e.g., PowerPoint presentations) had several benefits. He noted that students were more interested and were a lot more eager to engage in the activities at hand. The fact that all students participated in such technology driven activities was not only notable but also a very positive change in terms of how students were developing their knowledge and understanding. Ameen also claimed that "rather than [the teacher] explaining," the students were actively researching and learning through their exploration. In this way, they were comprehending the real implications of the content a better, and also "retain[ed] that knowledge longer".

Ameen also created interactive quizzes using the PowerPoint presentation. This was a useful formative assessment tool which the students engaged with as part of their homework. He noted that the students completed the quizzes without difficulties. Thus, though the quiz has simple short answer with recall type questions, Ameen believed it had several benefits for both his students and him. First, to progress from one question to the next, students needed to get the answer right, which meant they would learn the solution as they go along. Also, it allowed students to get results instantly, without having to wait for the teacher to mark their answers the next day, saving much time for both teacher and students. Interestingly, he mentioned that he sometimes got the students create similar types of quizzes on topics he assigned and got them to exchange them with their peers to try out. He believed that this was a great way to help students revise their work as they would need to go through the content and know the correct answer to create and verify their quizzes.

Impact of technology use on teaching and learning

The two-dimensional matrix below summarises how Ameen used the technology (SAMR) and the perceived impact on students' cognitive engagement (BDT) (see *Figure 5.3*).



Key: A - PowerPoint presentations, videos (teachers)
B - Interactive quiz (student)
C - Share materials (PowerPoint presentations of the lessons) (teachers)
D - Collaborative research activities, multimedia presentations, (students)

Figure 5.3 Two-dimensional matrix to visualise Ameen's technology implementation and the perceived impact on student's cognitive engagement

As seen from *Figure 5.3* above, Ameen's use of technology (PowerPoint presentations, videos) to explain his lessons led to task enhancement (Puentedura, 2012). The use of PowerPoint presentations and videos augmented the learning task by allowing some functional improvements (e.g., revisit important content/ points quickly by switching back and forth between slides/ scenes and quickly revising at students' convenience). Likewise, the interactive quizzes given to students also served as a substitute for paper-based quizzes, with some functional improvements (e.g., control progression in the quiz, get instant results, and know the correct answer immediately). These benefits are consistent with those identified by previous researchers (Beauchamp et al., 2015; Keane et al., 2016; Patton, 2015). However, the use of technology had minimal impact on students' cognitive engagement, where it mostly helped foster their understanding and remembering skills.

In contrast, student’s use of technologies to conduct research and present their work in novel ways required higher cognitive engagement (analysing, creating) from them, aiding to develop the key competency skills (critical thinking, creativity, use technology and media) that are prescribed in the Maldivian national curriculum framework (Gebre et al., 2014). These activities evidence pedagogical shifts from the "teacher as the locus of knowledge, to the learners and learning" (Chandra & Mills, 2015, p. 288). Also, this student-centred use of technology to conduct learning activities transformed the teaching and learning process (Puentedura, 2012).

Influences that impacted teachers’ technology implementation

Ameen's beliefs about the advantages of technology (e.g., easy to explain, share materials, increased engagement, interactivity, and motivation) affected how he implemented technology in his classes. As seen from the preceding section, the formal training (two weeks of ICT training) bolstered Ameen's technological competence and positively affected his technology adoption strategies.

Furthermore, the support he got from the school management to use the technology resources in the staffroom for lesson preparation, and the efforts made by the management and the school Parent-Teacher Association (PTA) to generate funding to buy the technology resources (Smart TVs) also positively influenced his use of technology in teaching. However, as time went by, these resources (e.g., Smart TVs) got damaged, and replacements were not possible due to funding issues. This lack of resources, combined with the difficulties faced with booking shared resources (e.g., computer lab, AV room), prevented him from using technology the way he anticipated.

Even with the available resources, he believed that teachers should carefully consider the learning intentions of the activity before deciding on the technology. To clarify his point, he described the classroom management issues he encountered during a lesson on the topic of "divorce". According to him, "students got distracted because of the photo [he] included in the lesson", and though he managed to "successfully complete the lesson", he found it was very challenging. Ameen remarked that he used the photo of a couple sitting apart with their heads in their hands, which was neither sensitive nor the usual kind of image he used for other topics. Thus, he reasoned that a possible explanation for students' overexcitement was the topic was rarely discussed among students of this age group (15 - 16-year-old). Nevertheless, Ameen contemplated the importance of considering the content (images, videos) one should choose when designing lesson materials.

Also, in his opinion, not every technology can be suitable to conduct the lesson. To clarify this point, he described the classroom management challenges he faced when students used the tablet to do “activities not related to the lesson” while trying to explain the lesson. In his view, he needed to have complete control of the class during "explanation time". Thus, he believed that technology (e.g., students having tablets) could be a source of distraction in some situations, but he also agreed that tablets were helpful to get students to do the activities he planned.

5.5 TEACHER 2 - MALIK (SCHOOL A)

Malik was the youngest (28-Year-old) amongst the interviewed participants and taught mathematics at the current school for more than six years. At the time of the study, he was teaching year nine classes at this school. Before joining this school, he worked as a lecturer at a college in his home country, India. Malik did not have a formal teacher education qualification but possessed a Bachelor’s Degree in Engineering.

For Malik, his senior colleagues, and YouTube videos were instrumental in enriching his knowledge on using technology to teach Mathematics lessons. He contended that he regularly watched YouTube videos and visited a few other websites (e.g., GeoGebra, algorithm package, interactive maths) to keep himself updated. Whenever opportunities presented, he engaged in professional learning activities in technology provided by the school and Ministry of Education. One recent training he mentioned was the Google Classroom conducted by the Ministry of Education. When asked if the training sessions were helpful for him to integrate technology into his lessons, he reluctantly agreed. Through these sessions, he learnt several skills: how to add students to the Google Classroom, share documents, assign tasks, monitor student progress online, download and use applications on the tablet, or even create his resources (e.g., online quizzes).

> [The] teacher also wants students to learn effectively in anyway, whether using traditional way or by using technology … [however]… training [given] for us … [to teach] above-average students … how to use [technology] … is significantly less, it is lagging. If we get more training … it will be easy for us also, and the students also I believe. (Malik)

However, in his view, the training was insufficient, and he wanted to know how to deliver differentiated instruction based on student's abilities. Consequently, he wished to receive further training on using the technology to deliver more inclusive lessons. In this regard, Malik stated that through his research, he had discovered few good websites with valuable math resources, but he could not use those in his lessons due to the high subscription fees, which neither the school nor he could afford due to budget constraints. Thus, he anticipated future training opportunities to address this gap. That is, to cover topics on how and where he could access resources to conduct differentiated instructional activities to cater to different student abilities. According to the TPACK survey conducted in phase one, Malik's perception of the constructs was rated as 'high' (see Table 5.4).

Table 5.4 *TPACK survey results for Malik*

TK	CK	PK	PCK	TCK	TPK	TPACK
4.8	5.0	4.2	3.5	4.0	3.3	4.0

The data above suggests that Malik was very confident about his subject knowledge (CK) and technology knowledge (TK), suggesting a high motivation to learn and keep up with emerging technologies and solve technical problems. Also, he was highly confident with the pedagogical knowledge (PK) and technological content knowledge (TCK). However, Malik seemed to be slightly less confident with pedagogical content knowledge (PCK) and in applying pedagogies that were most appropriate with the identified technologies (TPK). The uncertainty highlighted here could be attributed to his lack of formal teaching qualification and also a lack of knowledge about applications specific to math that he could use for different pedagogical approaches. The survey data further indicated that Malik's experience of using technologies in teaching was 'average' (a few times a month, at most). Table 5.5 below summarises his familiarity and use of some of the commonly available technologies.

Table 5.5 *Malik's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	4	4
Assessment software. e.g., Online quizzes/ Tests	3	3
Collaborative software. e.g., Wikis, Google drive, Padlet	2	2
Multimedia creation software. e.g., Desktop publishing, Photoshop	5	2
Discussion forums/boards. e.g., on Moodle, Blackboard	4	3
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	3	3

Blogging apps. e.g., Weebly, WordPress, Tumblr	3	2
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	1
Tablet or iPad-based applications	5	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	5	3
Virtual classrooms	3	3
Adaptive Learning Platforms	3	3

The data above shows that although Malik had ‘high’ or ‘very high’ (score of 4 or 5) familiarity with presentation software, discussion forums, multimedia creation software, tablets and cloud-based apps, presentation software was the only technology that was frequently used in teaching. The analysis of the interview data from Malik offers further insight on these results as to why he implemented some technologies more than the others in his teaching.

Implementation of technology in classroom teaching

The interview data suggested that Malik's use of technology mainly was also limited to the Smart TV provided by the school to show PowerPoint presentations and videos. He also elaborated that Smart TVs were the only technology that was at his disposal in the classroom.

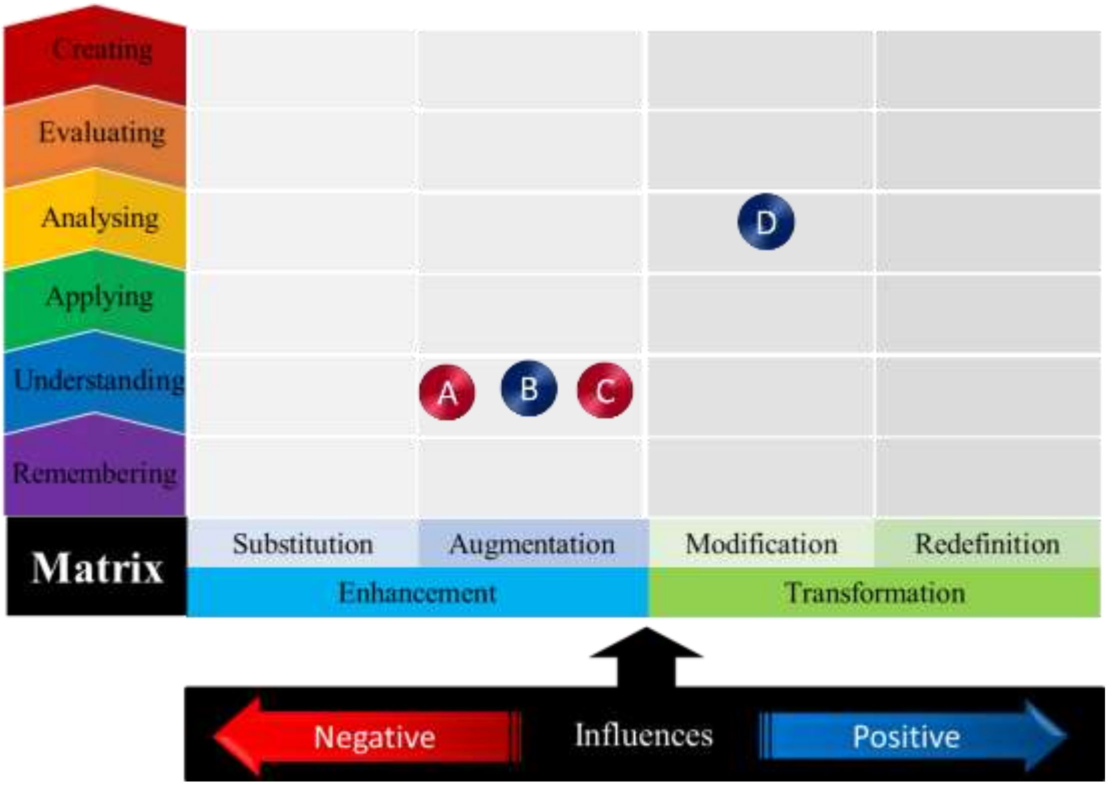
> Sometimes I use videos … [because] for every [topic], I cannot get animated versions … fuzzy problems like the angle of depression, angle of elevation…that kind of problems ... [students] need to understand, it is a real-time problem actually …. So instead of just going for the traditional method, if we can explain and get them through by videos, it is easier for me. (Malik)

While PowerPoint presentations and animated videos made it easy for Malik to explain some of the basic content, he felt that it was insufficient to teach some of the more abstract concepts. Thus, when MoE provided tablets to students in his school, he embraced the opportunity to engage students in lessons in "more interactive" ways. Consequently, he used an interactive app called "GeoGebra", which he thought was beneficial for students because they could create animations of difficult math topics and visualise changes in real-time. For example, many students in his classes found it difficult to understand the "circle theorem". His chalk and talk lessons even when supported by YouTube videos did not deliver the intended lesson outcomes. From Malik’s point of view, students needed "visualisation” so they could “understand" how the angles varied in the circle. According to Malik, the GeoGebra application enabled experimentation. Students can interact with the software to "vary the angle, or the lines and check how the angles changes". Subsequently, the software facilitated a deeper conceptual understanding of the circle theorem. Thus, he found that this kind of interactivity and real-time visualisation experiences made it easier for him to teach abstract topics and helped students to grasp the concepts easily. Malik reflected on the impact of using this technology by pointing out that GeoGebra considerably increased their comprehension and as a consequence, they "could solve the problems" with greater ease. Furthermore, he claimed that, even the "entrant students [slow learners]", found it "easy to ... grasp [the concepts]".

Nonetheless, Malik believed that technology cannot be used to teach all "topics in maths". This was due to a few reasons. First, the classroom lacked Wi-Fi connectivity and he had limited access to interactive content on different math topics (e.g., GeoGebra for geometry, algebra, and statistics). As a result, it was more convenient for him to explain the lesson content using the conventional 'chalk and board' method. Another challenge that prevented him from adopting technologies in his classes was related to student behaviour. For instance, with tablets, he sometimes encountered issues when "students [who were] good at technology … [mis]guided other students" into engaging in things unrelated to the lesson or misuse the tablets. Distracted students affected his lessons as he could not conduct the activities that he had planned due to these behavioural issues. He contended that as students became used to newly introduced technologies (e.g., tablets), it may not be as appealing to students as once first was (when introduced). As a result, he found that "after…a couple of classes, they [may] get bored… [and]… get distracted". Malik believed that with such innovations, student mentality shifts over time, and instead of "participating in the lesson", they preferred doing other things, which he found troublesome.

Impact of technology use on teaching and learning

Malik's implementation of technology and the perceived impact on students' cognitive engagement is conceptualised using the two-dimensional matrix below. The horizontal axis represents the level at which technology was used, and the vertical axis represents the level at which it impacted students' cognitive engagement (see *Figure 5.4*).



Key: A - PowerPoint presentations, videos (teachers)
B - Interactive quiz via Google Classroom (student)
C - Share materials via Google Classroom (PowerPoint presentations of the lessons) (teachers)
D - Virtual simulations using GeoGebra (students)

Figure 5.4 Two-dimensional matrix to visualise Malik's technology implementation and the perceived impact on student's cognitive engagement

As seen from *Figure 5.4* above, Malik's PowerPoint presentations and videos enhanced the learning activities. The technology resulted in some functional improvement (e.g., demonstrating, revisiting) in the activities. However, his adoption of GeoGebra went beyond simple demonstrations as students could visualise in real-time the changes that occur based on their input. The use of technology in this situation transformed the learning task (Puentedura, 2012) as it allowed for the modification of existing pedagogies and the delivery of learning activities. Instead of using a typical diagram or a video, the concept of how angles vary was illustrated using an interactive website with variables students can input and visualise the change in real-time.

Influences that impacted teachers' technology implementation

A number of factors influenced Malik's decision to implement technology in his lessons. For instance, although Malik believed in the benefits of technology in his teaching and student learning, he was wary of its unfavourable effects (e.g., students getting distracted) and believed that the technology adopted should be based on how much it can help engage students in learning. Moreover, he felt that the use of technology might not result in optimal learning outcomes for many mathematic topics. One main reason was the limited access he had to digital content on his subject and his lack of knowledge about where to find free resources. He also believed he required more professional learning opportunities especially on how to use technology to differentiate the instruction based on student ability levels.

5.6 TEACHER 3 – LIRGAM (SCHOOL A)

Lirgam worked as an English language teacher for students from Year levels Five to Ten. He is 35-year-old and has more than 11 years of teaching experience, of which eight years were at the current school and three years in his country India. Lirgam has done a Bachelor's Degree in Education and a Postgraduate Degree in Arts. Lirgam's technology competency, as measured by the TPACK survey, suggests he had a 'very high' TPACK, as shown in the table below.

Table 5.6 *TPACK survey results for Lirgam*

TK	CK	PK	PCK	TCK	TPK	TPACK
4.2	4.3	4.2	1.0	4.3	3.5	4.5

From the figures in Table 5.6, it can be seen that Lirgam's perception of his understanding of most of the knowledge constructs except PCK was high. The very low score for pedagogical content knowledge indicates that he lacked the confidence to adopt productive teaching approaches to guide student thinking and learning and help them understand the content in his subject without using technology. However, the discussion below on his pedagogical practices shows that he adopted different teaching approaches to guide students' thinking and learning and help them understand the content of his subject. This was contrary to how he perceived his PCK abilities, which indicates that he had underestimated or misunderstood the scale items measuring PCK in the survey. This inconsistent result is discussed further in chapter six (see Section 6.2). A summary of his familiarity and use of some of the commonly available technology is shown in Table 5.7 below.

Table 5.7 *Lirgam's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	4	4
Assessment software. e.g., Online quizzes/ Tests	4	3
Collaborative software. e.g., Wikis, Google drive, Padlet	2	2

Multimedia creation software. e.g., Desktop publishing, Photoshop	1	1
Discussion forums/boards. e.g., on Moodle, Blackboard	2	2
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	1	1
Blogging apps. e.g., Weebly, WordPress, Tumblr	4	2
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	3
Tablet or iPad-based applications	3	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	1	1
Virtual classrooms	1	1
Adaptive Learning Platforms	1	1

According to the table above, Lirgam was highly familiar with presentation software, assessment software, and blogging apps. However, the most frequently used technology from these was ‘presentation software’ only. These findings are further investigated in the consecutive sections to get more insight and understand his reasons for mostly adopting PowerPoint Presentations.

Implementation of technology in classroom teaching

Lirgam's interview data suggested that he was motivated to adopt technology and made use of the minimal resources that were at his disposal in his classroom. Like his contemporaries (Ameen and Malik (Sections 5.4 and 5.5)), Lirgam also predominantly used technology (Smart TV in the classroom) to deliver PowerPoint presentations. This also corroborated the survey finding presented in Table 5.7, which showed that he mostly used 'presentation software' to conduct lessons. In his view, technology enabled him to facilitate his lessons with greater ease and, in the process, have a "huge effect on the student's" understanding. He reflected on his use of YouTube videos to explain review writing to students as an example to support his argument.

> [I]f I want to teach … let’s say a review writing, I can use this technology. I can do a presentation or … even I can show a movie so they can understand … (Lirgam)

Instead of him explaining, he believed that using technology (e.g., video) helped students understand how to do a review exercise easily. In his view, technology benefited him as well since he did not "need to struggle that much" when explaining the lesson. However, he confessed to needing extra time "to prepare [for the lesson] prior". Furthermore, he shared his experience of using "Google Classroom to share materials with students" via the tablets provided to them.

> We do some tests through google classroom … no need to use a book or pen to write. Just directly they can give the answer. For example, I can share the question paper, on

> the google classroom, no need to print, no need to distribute. Simply with one click, I can reach the students, and even they can send it back. Even I can do … the correction work at home. (Lirgam)

As evident from Lirgam's explanation above, adopting technology this way was beneficial for him and his students as it allowed him to easily "reach the students" with just "one click, and share question paper" with them. It also made it easier for his students to "directly answer" and "send it back" to the teacher. This way, he could work and "correct students work from home" without the need to "carry books or print and distribute question papers." Thus, he believed that technology allowed more efficiency in teaching and learning activities (e.g., marking and providing feedback on students' works online).

Further, to help develop students' writing and speaking skills, he gave students activities that required them to work collaboratively. As an example, in one of the activities students were instructed to "draw the structure of the new school … with landscape and all" using any drawing application of their choice. They could use applications such as PowerPoint, Paint or Word. As part of this task, they had to deliver a presentation on the ideas that they had envisaged for their new school. Lirgam believed that conducting such activities helped develop students' creativity and critical thinking skills (e.g., design of their structure for the new school), collaboration (e.g., working in groups), and speaking skills (e.g., presenting their work to class). Also, the technology (tablet) afforded students to draw (e.g., using PowerPoint) and describe their artefacts. Lirgam perceived that this sort of activity made the lesson more interesting for students and helped him achieve the desired outcome more easily (i.e., develop students writing and speaking skills).

Though Lirgam believed in the above benefits, he also considered "how effective" technology was for the lesson. For example, instead of getting students to do a writing exercise (e.g., letter, essay) "using their tablet", he believed that it would be easier and as effective even if he asked them to "write on a piece of paper instead of typing it". So, even if students liked to use technology, he believed that asking them to do the writing on the tablet, just for the sake of using technology, "would not work in the classroom". Moreover, students' misuse of the technologies was also a concern for him. Because "When they [students were] given work, they [do] something else", and he found it "difficult to control" and manage their engagement with the tablets.

Lirgam highlighted the support he received from the management in getting some of the technologies into the school but found it challenging when the management could not solve problems once the devices stopped working. According to Lirgam, the issue of malfunctioning Smart TVs and speakers had lingered on at least two years:

> [S]chool management had provided many things. But the TV and facilities are not working properly right now … for the listening … even for public examination we use TV … it's a poor condition [TV] … we started using tablets three or four months back. But within two, three months, we lost the Wi-Fi … (Lirgam)

Lirgam was gravely concerned about the resources needed to conduct lessons, especially about resources needed to conduct listening activities. Like Ameen, he believed that the management needs to be more supportive in providing the resources and fixing the issues with faulty devices/tools. He highlighted that many of the resources they currently have in the school were more than four or five years old and thus needed maintenance and upgrading. For instance, he mentioned that all the resources in the AV room were working when it was initially set up but deteriorated with time. Although he had some support, he felt that management had been unable to resolve the resource issues but understood that this was due to factors outside their control (lack of funding).

Another impediment for Lirgam was the restrictions imposed by the MoE on search engines and app installation on the tablets given to students. He explained that the issue was that "they [students] do not have any search engine on their tablets"... and therefore "cannot do any searching on the tablet itself." They can only use "the things that are downloaded on the tablet". The Ministry imposed this restriction on the device primarily for security reasons. Thus, despite students having a sophisticated device, its use in carrying out activities was limited.

Lirgam contended that he did not have sufficient knowledge and wanted to learn more about integrating technologies in his teaching. He attributes most of his knowledge to self-study via Google and YouTube and exchanging knowledge among colleagues. The weekly department coordination meetings were also a vital learning forum for Lirgam, as teachers exchanged the strategies, they adopted to deliver the curriculum in innovative ways in these meetings. He also talked about some formal training he did on Google Classroom for education. The training required him to go through the online course content and complete the activities. Lirgam believed the training was beneficial because this was the first time, he heard about Google Classroom and how to apply it in his teaching. The training helped him start using Google Classroom (e.g., share materials, conduct online assessment) in his teaching. However, Lirgam stated that he could not recall much of what he learned from the course. He felt overwhelmed with its content and believed that sufficient time was not given to complete the training.

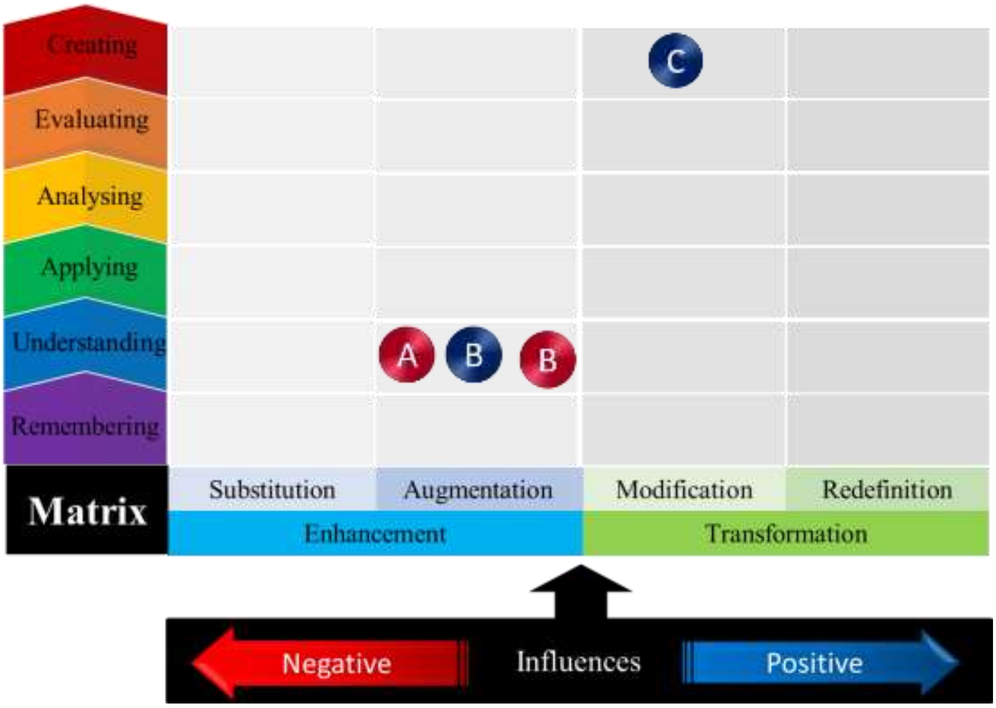
> [With] the Google Classroom … there were so many [content] … but to be honest, I couldn't study everything in proper time. I mean the provided time was not enough for the studies … [I had to] learn this myself … [and] I do not remember what was covered in the training (Lirgam)

Thus, though Lirgam completed the training, he felt he was not confident with his technology skills and "still needed more training" on using digital technology to conduct learning activities (e.g., multimedia, and collaborative tools). Also, he preferred more personalised face-to-face training from a facilitator on "how to use all these applications" rather than online training.

Impact of technology use on teaching and learning

Lirgam's technology integration and the perceived impact on student's cognitive engagement are mapped in *Figure 5.5*. Lirgam's use of PowerPoint presentations and videos to conduct review writing activities augmented the learning activity. Likewise, the use of Google Classroom to share materials and assessments also resulted in functional improvement to the tasks, without any significant shifts in student learning. In both these cases, technology-enhanced the learning task (e.g., more straightforward to show a video demonstrating how to write a review; more accessible to share materials on Google Classroom).

However, the use of tablets by students to design a structure for a new school required them to explore and critique different school structures to come up with their recommendation. Students had to choose an app to design their new structure, collaborate with their peers, develop the artefact, and present their work to the class. This task required higher cognitive engagement from students to analyse, evaluate and create the artefact. Thus, the use of technology helped modify the task (Puentedura, 2012), resulting in the transformation of existing pedagogies and learning activities for students.



Key: A - PowerPoint presentations, videos to conduct listening/ review writing activities (teachers)
B - Share materials, assessments online (Google Classroom) (teachers & students) (teachers & students)
C - Draw new school structure & present their artefact to class (students)

Figure 5.5 Two-dimensional matrix to visualise Lirgam's technology implementation and the perceived impact on student's cognitive engagement

Influences that impacted teachers' technology implementation

One of the main influences on Lirgam's technology integration was his belief about the ease technology brought for him and his students. Technology created a platform where he could share resources more effectively and provide feedback on students work more efficiently. He also believed that using technology made the lesson more effective (e.g., showing a video of review writing activity), and he need not struggle to conduct the lesson later on.

He also identified several influences that hindered him from adopting technology in his lessons. The biggest issue was the lack of classroom facilities and resources and the condition (damaged) of the limited resources. Since many of the existing resources (e.g., TVs in the classrooms) were malfunctioning, teachers had to compete to access the limited resources. Another issue was the security features installed in the tablets. According to Lirgam, the students could not access additional sources or research, as the tablets did not have a search engine function or authorisation to download and install apps. While he understood the reason for this restriction, Lirgam found that it limited the activities he could conduct with students using tablets. The suitability of the technology for the intended learning outcome (e.g., getting students to write an email on the tablet versus on the paper) and students' misuse (e.g., doing things unrelated to the lesson) was also essential considerations Lirgam highlighted.

5.7 TEACHER 4 – ANIL (SCHOOL B)

Anil, 36, has been teaching physics to secondary level students (14- to 16-year-olds) for over eleven years. At the time of the study, Anil had been at School B for over nine years and taught Year Nine and Ten classes. Anil has Bachelor's Degree in Computing, a Degree in Teaching, and at the time of the study, he was pursuing a Postgraduate Degree in School Management. According to his interview, Anil used technology in all his lessons, and the most common use was to project presentations, pictures, and video clips that he sometimes designed using Moviemaker or downloaded from the internet. He believed using technology could enhance students' understanding and lead to improved academic performance.

Anil attributes his initial interest and knowledge of technology to the computing degree and the teaching degree he did as an undergraduate student. He then acquired more knowledge from the workshops and training opportunities he had at the school and from the Ministry of Education. The most recent training he completed was the tablet training programme conducted by the Ministry of Education. Under this programme, he had completed training on Google Classroom. In addition, he had also done training on Microsoft educational community. In Anil's opinion, the training programs were beneficial and have aided him to incorporate technology more effectively in his lessons. His understanding of the knowledge required to use technology as identified from the TPACK survey is shown below.

Table 5.8 *TPACK survey results for Anil*

TK	CK	PK	PCK	TCK	TPK	TPACK
4.5	4.0	4.8	2.0	4.0	4.0	4.0

Based on the above figures, it can be seen that Anil’s perception of all the knowledge areas was high except for pedagogical content knowledge. The low PCK score implies that, like Lirgam, Anil also had lower confidence in adopting various teaching approaches to guide student thinking and learning and help them understand the content in his subject without using technology, which contradicts the interview findings discussed below. The interview analysis shows that he had a sound understanding and applied various pedagogical strategies to help students think and learn his subject’s contents. Thus, like Lirgam, Anil underestimated his PCK abilities while completing the survey and needs further elaboration, which is discussed later in chapter six (see Section 6.2). Table 5.9 shows a summary of Anil's familiarity and use of some of the commonly available technology.

Table 5.9 *Anil's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	5	4
Assessment software. e.g., Online quizzes/ Tests	4	3
Collaborative software. e.g., Wikis, Google drive, Padlet	1	1
Multimedia creation software. e.g., Desktop publishing, Photoshop	4	2
Discussion forums/boards. e.g., on Moodle, Blackboard	1	1
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	4	3
Blogging apps. e.g., Weebly, WordPress, Tumblr	4	2
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	4	3
Tablet or iPad-based applications	4	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	4	3
Virtual classrooms	4	3
Adaptive Learning Platforms	4	3

The above figures show that except for 'collaborative software', and 'discussion forums', Anil's familiarity with most of the technologies was 'high'. However, like other participants, the only technology he frequently (at least one or more times a week) used was 'presentation software'. The interview held with Anil gave further insight into these findings.

Implementation of technology in classroom teaching

Based on the interview and the document artefacts Anil shared, it was evident that most of his lessons usually followed three steps. For example, in teaching any topic, Anil first tests his students' prior understanding of what he planned for the day by assessing them through an interactive MCQ type quiz, via an online website like menti.com, provided he and students had internet access (*step1*). These questions are "theory-based based, no logical thinking, directly from their work" and therefore had "lower-level questions" to elicit "participation for everyone". The website allowed him to view each students' score on the quiz. In classes where internet access was a problem, he used PowerPoint-based game activities (see *Figure 5.6*, images 1 and 2) to elicit students' understanding.

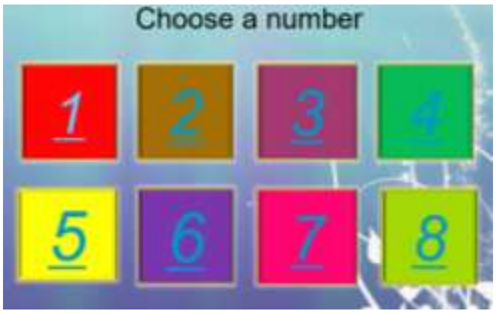


Image 1

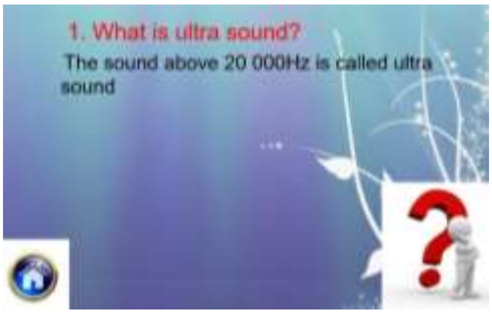


Image 2

Figure 5.6 Example of a game activity to gain student understating of the key contents

He then proceeds with the lesson, focusing on the areas of weakness identified from students' answers (*step 2*). Anil mainly uses PowerPoint presentations (see *Figure 5.7*, images 3 and 4) when explaining the lesson. He also mentioned using videos to show "experiments that cannot be demonstrated in the class". He believed it helped students grasp scientific concepts more easily by allowing them to "observe experiments as frequently as they like using YouTube videos". He also shares the materials he uses in the lesson with students through Google Classroom.

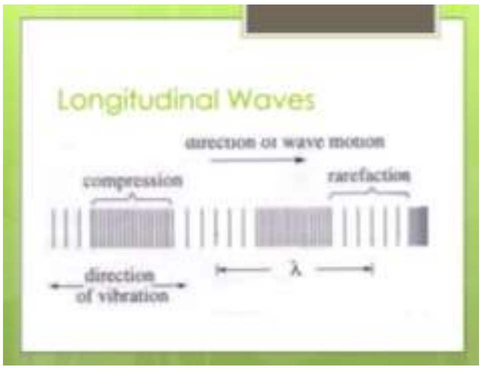


Image 3

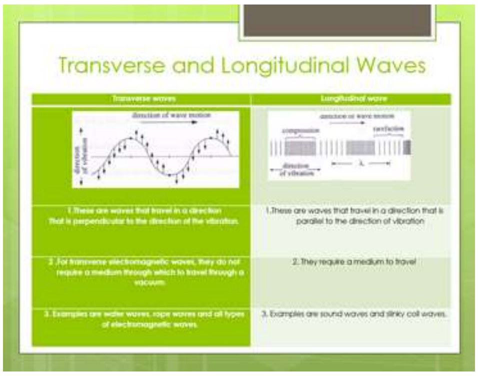


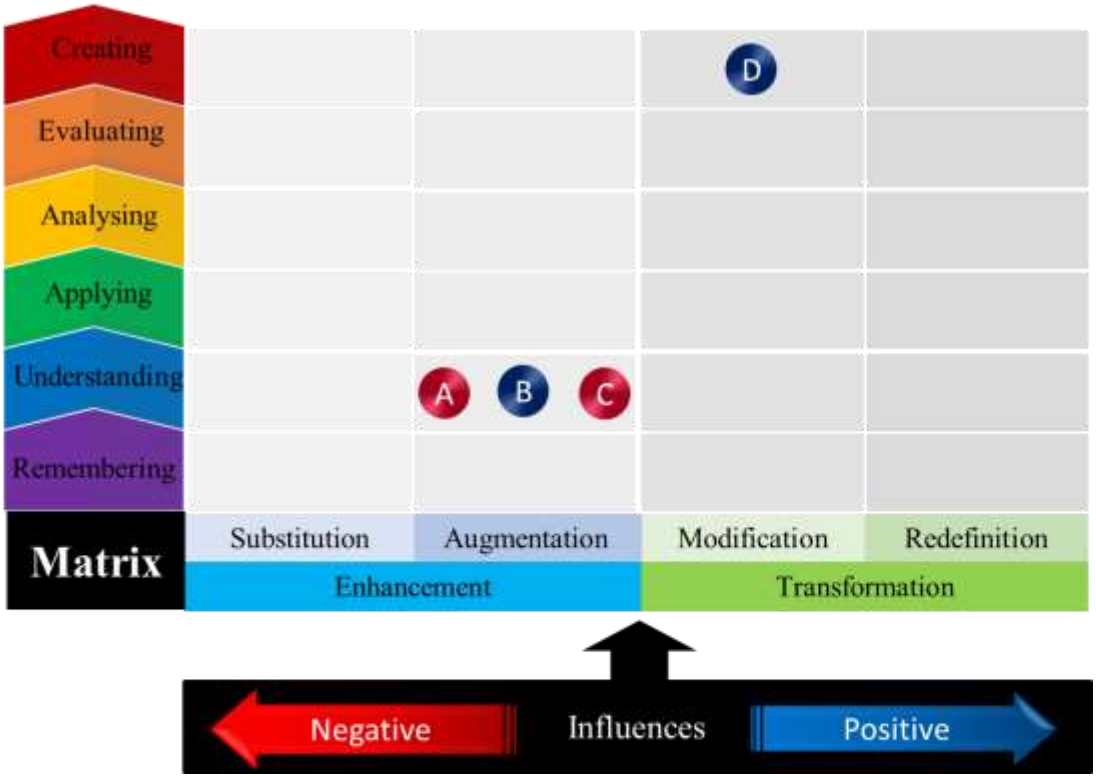
Image 4

Figure 5.7 Example of a lesson used to explain "wave properties"

Next, to reinforce learning, he had students work individually or as groups (ability based) on activities/problems related to the topic (*step 3*). As an example, he talked about the activity he assigned to students on 'electronic components'. Student groups with lower understanding of the topic were assigned to "make a presentation about the [electronic] components", while other groups were required to conduct "experiments using the real components" and then create presentations. Students then explain their work to the rest of the class. Anil believed that, besides engaging students through technology, this strategy allowed his students to work collaboratively to solve problems, develop their knowledge of the topic, and their communication and presentation skills.

Impact of technology use on teaching and learning

Anil's implementation of digital technologies, and the perceived impact on student's cognitive engagement are shown in *Figure 5.8*.



Key: A - PowerPoint presentations, videos to explain, demonstrate experiments (teachers)
B - Online quiz via menti.com (student)
C - Share materials via Google Classroom (teachers)
D - Create PowerPoint presentations on electronic components/ circuits (students)

Figure 5.8 Two-dimensional matrix to visualise Anil's technology implementation and the perceived impact on student's cognitive engagement

Anil's use of PowerPoint presentations and videos to teach and demonstrate experiments and Google Classroom to share materials augmented the learning activity. Similarly, his use of an online website to conduct quizzes resulted in functional improvement of the tasks (e.g., instant student response allows him to assess their understanding in real-time) without significant shifts in student learning. In all these cases, technology was used to enhance the teaching and learning tasks (e.g., use videos to show or demonstrate experiments easily, allow students to view videos repeatedly; easily share and access materials online).

However, allowing students to design electronic components/ circuits required them to explore and experiment to develop a working model. Besides understanding, they had to use higher cognitive skills (apply the knowledge to analyse, evaluate and create the model circuit). Thus, the use of technology in this situation transformed the learning task (Puentedura, 2012) as it modified existing pedagogies and learning activities for students. In addition, they also had to collaborate with their peers during the whole process and present their work to the class, skills which are required for their future workplace.

Influences that impacted teachers' technology implementation

Anil's exposure to technology training at an early stage of his career equipped him with knowledge and skills he could apply in his teaching and positively influenced his beliefs towards technology integration. Thus, he firmly believed that technology had numerous benefits to him as a teacher and his students. For instance, he believed technology had many advantages (e.g., YouTube videos: to show experiments that cannot be demonstrated in the class, repeatedly watch videos, and the visuals help students easily grasp physics concepts). Moreover, he believed that students' keenness towards digital technology meant greater participation, broader thinking, and improved achievement. Anil's use of technology was also associated with his views about its suitability to the topic, the type of activities possible, the lesson objectives, and the avenue created to cater to the needs of diverse groups of students.

Furthermore, the support from his school leaders seemed to have motivated Anil's technology integration. He specifically recognized the principal as a supportive leader who continuously encouraged teachers to incorporate technology in their lessons by introducing them to "new [technology applications] that are available on the internet … for example, some website or some software". Further, Anil recognised the school management's efforts in making technology resources accessible to teachers. He stated that "within the [budget] limitations", the principal strives to replace "the old systems and then [setting up] multimedia in different locations … [and] increase the speed of internet".

Anil also acknowledged the MoE's support in driving the technology agenda in schools. For example, he highlighted the 'Digital school' project introduced by the Ministry, where students and teachers were provided with a tablet. Anil's involvement as the school coordinator for the project made him appreciate the initiative, and he firmly believed in its benefits. However, despite these positive beliefs, Anil expressed concerns over its implementation. He maintained that although teachers were trained for the project initiation, enough was not done at school or even at a national level to successfully implement the tablets in schools. Major issues Anil raised include the lack of clear policies from the MoE regarding the tablets and the lack of classroom wi-fi. For Anil, this was a significant issue as it prevented him from conducting online activities (e.g., online MCQs, YouTube videos) with his students. Combined with these issues was the lack of support from IT staff.

> We don't get support from the right people … from IT technicians or the administrative side, we don't get that … for example, if I asked to set something, and if we request two or three weeks before, it will not be done ... like that technical support … or even software updating and all (Anil)

As evidenced from the above quote, the lack of support from technical staff can be a significant impediment to Anil and all the other teachers and the school management who rely on the IT technician's support to maintain and keep the systems functioning and up to date.

Lastly, Anil shared the challenges he faced due to the limited time (35 minutes) allocated for each session or class. His concern with time allocation was associated with the movement of students and teachers in between sessions to access shared resources (e.g., Audio-visual room, computer lab). Anil revealed that "to move [students] to a particular location, it consumes time and results in waste [of] five to seven minutes", and by the time students got settled, he found that much valuable time from the lesson was gone, and therefore he could not conduct the lesson as planned. Thus, he believed that the time allocated for each lesson needs to be extended to give leeway for this 'lost' time in switching between venues.

5.8 TEACHER 5 – SUMA (SCHOOL B)

Suma, 44, has been teaching Business Studies to Year levels Eight, Nine, and Ten at School B for over 16 years. Before starting at this school, she had two years of teaching experience in India. She holds a Bachelor's Degree in Education and a Postgraduate Degree in Business and Commerce. Suma described her knowledge of technology as very limited when she first started teaching. This included the Microsoft Office training she received while in India, but she was never able to apply the knowledge in her teaching at that time.

Nonetheless, after starting her job as a Business Studies teacher at the current school, she gradually began adopting technology in her lessons. Suma owed it to her school's principal, whom she described as a supportive leader who recognises and appreciates teachers' efforts. The principal, according to her, pushes for and supports teachers to use digital technologies so that learning becomes more fun and engaging for students.

Suma credits her technological knowledge to the training given by her school, the Ministry of Education, and her own practice. The training made her see the value of technology in the classroom. She had learned about Google Drive, Google Classroom, and Google Docs, which according to her, she had never heard about before undergoing the training. Nevertheless, Suma felt that these trainings were insufficient as teachers lacked awareness of informational resources to integrate technology into the curriculum. To overcome these limitations, she stated that she did acquire knowledge from her colleagues and sometimes from her students. She acknowledged that teachers, though mature, "cannot know everything" and that students were "90% better than [teachers] with technology [and] even subject knowledge." Suma claimed that teaching was a process that often involved learning, and thus learning about technology from students was not a problem but rather something fun and enjoyable.

The data below (see Table 5.10) suggests that Suma had a 'high' TPACK competence (mean score of 4) and frequently adopted technology (one or more times a week) in her lessons.

Table 5.10 *TPACK survey results for Suma*

TK	CK	PK	PCK	TCK	TPK	TPACK
4.5	5.0	4.2	4.5	4.0	4.3	4.0

As evident from the above figures, Suma perceived highly on all the seven TPACK knowledge domains, suggesting an in-depth understanding of her subject content and high confidence in her technical skills to solve problems, guide students' thinking and learning using appropriate technologies, and pedagogies. The data also indicates that Suma was highly confident in combining the subject content, technologies, and teaching approaches, to enhance teaching and learning. Table 5.11 below summarises her familiarity and use of some of the commonly available technologies.

Table 5.11 *Suma's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	5	5
Assessment software. e.g., Online quizzes/ Tests	3	4
Collaborative software. e.g., Wikis, Google drive, Padlet	4	3
Multimedia creation software. e.g., Desktop publishing, Photoshop	4	4
Discussion forums/boards. e.g., on Moodle, Blackboard	3	3
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	4	5
Blogging apps. e.g., Weebly, WordPress, Tumblr	2	2
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	4	5
Tablet or iPad-based applications	5	5
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	5	5
Virtual classrooms	5	5
Adaptive Learning Platforms	4	4

Based on the figures in the above table, it can be seen that Suma was highly familiar with 'presentation software', 'tablets', 'cloud-based apps', and 'virtual classrooms, and used these almost every day. In addition, she also indicated using 'web-based social media platforms and 'interactive boards' daily in her life. These results suggest that, unlike the previous participants, Suma seems to make wider use of technology in her teaching, which is explored through the interview held with her and follows next.

Implementation of technology in classroom teaching

Like others, Suma primarily uses PowerPoint presentations and videos projected on a white screen to show content related to her subject during lessons. She rationalized that it allowed her to share more information in less time, making it easy to deliver the lesson. She believed that the visual aspect of presentations makes them more appealing to students and thus increases student motivation. Suma felt that students could concentrate better when using different multimedia (e.g., images, audio, video) rather than "just orally explaining". Also, Suma used online MCQ quizzes created on Google Classroom to assess students' understanding of the lesson. She stated that this allowed her to assess the learning gaps quickly. Based on this information, Suma decides the appropriate learning strategy to adopt for different students.

The interview analysis revealed that Suma often considered her students' use of the technology for more authentic learning experiences. One example was the peer teaching activities conducted in her classes. She had her students work collaboratively in groups to research (on topics she assigns) and create "PowerPoint presentations [and teach] the whole class". She found that these strategies helped students learn and improve when they prepare and engage with the materials while learning from their peers. Also, she sometimes converted these activities into competitions where students strive to develop the best presentation. She believed these activities help students "revise the topics [and prepare] for their exams". She also noted that she learned a lot from her students, "mostly [on] technology [related] things."

A second example was the market research project she assigned to her students (see *Figure 5.9*). For this project, students worked collaboratively using digital technologies (e.g., MS Word, Excel, PowerPoint) to "prepare [the] questionnaire [and] conduct the survey [...] with the people in [the capital city], analyse, and deliver the results to the class".

Project on Marketing

Topics: Market segmentation and Primary market research

[redacted]

- The information you collect must be presented in the form of a power point presentation and a booklet.
- Aim of the project is to give students a chance to practically involve in some role of marketing and get more knowledge of the markets and experience of different market research methods.

- **Task 1**; Carry out a small primary market research for an university to study abroad. The research should be done based on the given four universities.
- University opportunities are **Stanford university (Stanford)**, **Harvard University (Cambridge)**, **University of Cambridge (Cambridge)**, **University of Oxford (Oxford).**
- Research information could include (Accreditation, Overall Cost of the course, Academic Quality, Courses etc.)
- First **select one type** of primary research like interviews, questionnaires etc.
- **Prepare a set of minimum 4 to 6 questions** to get the necessary quantitative and qualitative data.
- Then fill the questionnaires with the help of different students.
- **Select the sample type and size.** The total number of participants of the research can be between 10 to 20 students.
- **Collate and present the data** in any two ways of presenting market research data such as pie chart, bar chart etc.
- **Write a small report** about the findings of your research as a paragraph
- Gather pictures/photos related to the university, locations, selected from internet, books, magazines, newspapers or draw it etc.

Figure 5.9 Example of project work assigned to students (conduct market research, compile a report, and give a presentation on it)

She claimed that providing students the opportunity to research and discover themselves made the learning experience authentic and more meaningful. According to Suma, the ubiquity of technology offers an accessible channel for student and teacher collaboration. Consequently, she used 'Viber', a social media platform, to create different ability groups and share subject-related materials and assessment questions.

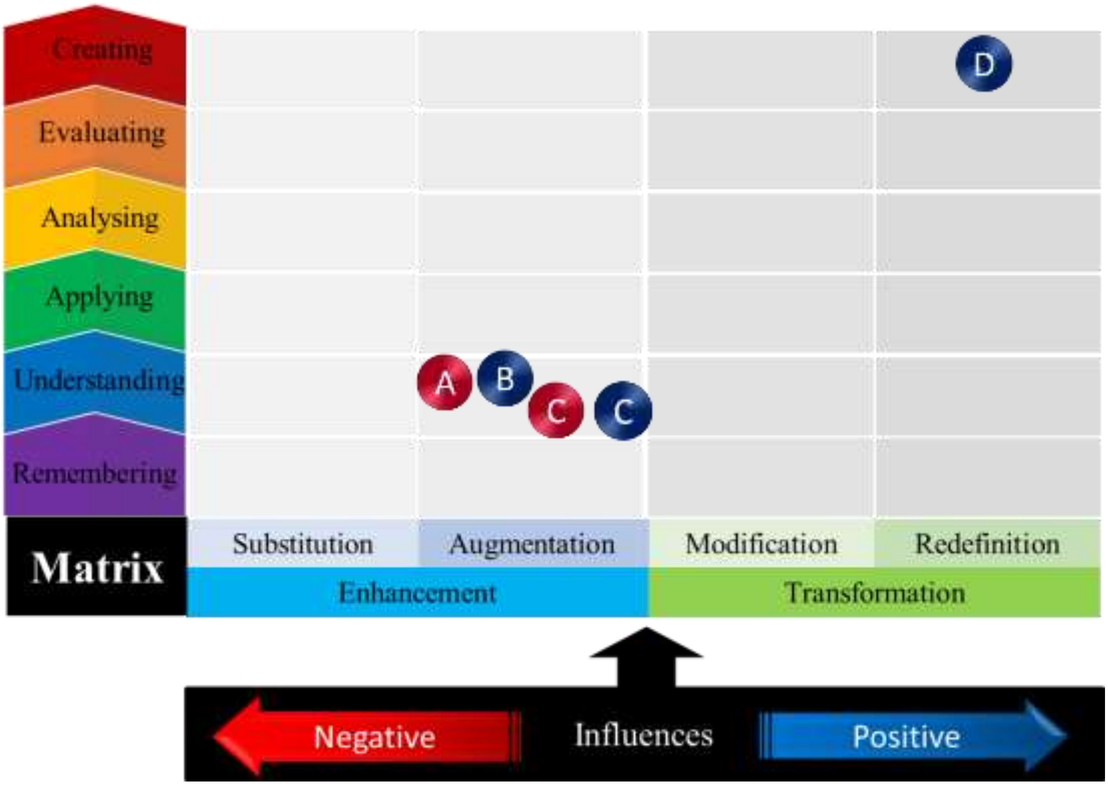
> [I] have separate Viber groups … based on their marks and knowledge … that is also technology, right? … I will be sending them questions, papers … [and] they are responding … I have all the topic wise questions, because we cannot give all of them the same topics, same questions … some are a little bit weak, some are very good … so we have categorised … I actually type and then [share on Viber] … as a screenshot … [students] answer and … post me the screenshots … [via Viber] … because of this Viber group … [students] can easily get access with me … even before the exam, after the exam, now also…practice is going on … they will keep on asking doubts ... (Suma)

Suma felt this was an easy and convenient medium to share resources with her students and give them immediate feedback and thus, was an essential means to help students with their ongoing learning. She believed that facilitating students with this level of access to the teacher helped keep them motivated and improve their learning. She proudly remarked about the accomplishments of one of her students who "got the top ten best in the school" because of the access technology (Viber) created for both teachers and students.

Impact of technology use on teaching and learning

The two-dimensional matrix in *Figure 5.10* conceptualises how Suma has implemented technologies and the perceived impact on student’s cognitive engagement. The PowerPoint presentations, YouTube videos, Viber, and Google Classroom used by Suma and her students enhanced the teaching and learning activity. It helped Suma to easily share information, while the visual aspect of videos and images enhanced student understanding. Also, Viber and Google Classroom to share materials and assessment activities (e.g., questions, online quizzes) helped both her and the students analyse student understanding and the knowledge gaps quickly. However, digital technologies in these examples did not result in any meaningful shifts in the learning outcome.

In contrast, the market research survey and peer teaching activity required students to work collaboratively to create and present their work using a range of digital technology tools (e.g., internet, PowerPoint, videos). These activities show a significant pedagogical shift in the task, where students were required to use higher cognitive skills (e.g., analyse market research data, evaluate, and create and present their report), thus transforming their learning. Using digital technologies in this way helped redefine learning by creating avenues for students to carry out the task in entirely new ways, which could not have been possible without the technology (e.g., collaborate and research online) (Puentedura, 2012).



Key: A - PowerPoint presentations, YouTube videos to explain (teachers)
B - Online quiz via Google Classroom (student)
C - Share materials via Viber (teachers & students)
D - Conduct market research, Create PowerPoint presentations (students)

Figure 5.10 Two-dimensional matrix to visualise Suma's technology implementation and the perceived impact on student's cognitive engagement

Influences that impacted teachers' technology implementation

Suma's decision to use technology in her lessons depended on several reasons. She believed that technology facilitated her teaching as well as student learning. According to her, technology opened a "wider space" and "more choice" of resources for her to prepare the lessons. She further argued that it helped her "save […] time and cover the syllabus much more easily". Although she had positive beliefs, her use was limited due to a lack of resources.

For example, she could rarely use the Smart boards at the school, mainly because they had just two Smart boards in working condition. Getting access to the Smart boards was a huge challenge because these were located in the labs, usually occupied by computer studies and science classes. Lack of resources also impeded her ability to conduct learning activities inside the classroom as well. Examples include the peer teaching and research activities (described earlier) her students did. They had to prepare for the activity at home rather than in class, mainly due to Wi-Fi access issues inside the classroom.

According to Suma, the lack of Wi-Fi significantly impacted other academic activities as well. For instance, she explained how their department teachers planned to conduct technology-based activities once the tablets were introduced. In preparation, they had all completed the Google Classroom training and prepared activities for use with Google Classroom. However, teachers could not "create the Google Classroom and post the things due to the lack of Wi-Fi access" for students inside the classrooms. Anil, who worked at this same school (see Section 5.7), also reported this as a significant obstacle to conducting online activities during lessons.

Moreover, unanticipated technical problems (e.g., projector or Smart board not working, unable to login to the system) and her lack of technical experience were additional challenges for her use of technology. She stated that the lack of authorization to access (to log in) computer systems in some locations (e.g., computer lab) prevented her from using technology to conduct the lessons. In such situations, teachers had to wait for "people who have access [authorization]," which resulted in a waste of class time and thus, prevented teachers from using technology to conduct lessons.

Lastly, Suma discussed the challenges she faced due to student's behaviour when using digital technology.

> when we ask students to bring their laptops or their iPads … student behaviour also sometimes will be drawback … some will be mischievous … unethical sometimes … because girls and boys both are there … they may take the photos of the girls and even mine …because now very easy right … they can do anything … that kind of disciplinary issues, fear is there (Suma)

This was related to her fear of the ethical issues that might arise, especially the school being co-ed; she believed there could be an opportunity for students to misuse technology (e.g., take photos and misuse it). Hence, although teachers were inspired to utilise technology, she noted that they required additional training on addressing these issues and implementing technology effectively in teaching.

5.9 TEACHER 6 – FARIYAL (SCHOOL B)

Fariyal is a 50-year-old teacher from India and has been teaching the English Language for more than 24 years, of which 14 years were spent at school B. At the time of the study, she taught English to students at Year level Nine and Ten. Fariyal is a qualified teacher and has a Master's Degree in the English language. Fariyal attributes most of her technology knowledge to self-inquiry and learning from friends. Also, she sometimes learned from her students, who she believed were the "best teachers regarding … technology because they are well versed". Besides, she had done some training conducted by the school on "different techniques [teachers] can follow in teaching" using technology. However, she could not recall the specific details of her knowledge or skills from the training. She also mentioned the Google Classroom training conducted by the Ministry of Education in preparation to launch the tablet program. Fariyal confessed that though the training was helpful, it was not sufficient for her to apply in her teaching.

> [Technology] is good to use, but we could have been given training … long term training … practical training like that. It could have been given instead of learning … [making] it is available online … but anyway, personally, when you do it, it will be still better (Fariyal)

As evident from the above comment, Fariyal believed that the way training was carried (online) out needs to change. In her opinion, the training needs to be more practical oriented and longer in duration. Yet, the quantitative survey done in phase shows that Fariyal frequently (one or more times a week) used technologies in teaching. The following table shows Fariyal’s competency to use technology based on the survey.

Table 5.12 *TPACK survey results for Fariyal*

TK	CK	PK	PCK	TCK	TPK	TPACK
3.8	4.0	4.0	4.0	3.7	4.0	3.8

As seen from the figures in Table 5.12 above, Fariyal's perception of her understanding in all the knowledge domains and the overall TPACK was 'high'. More specifically, the data indicates that Fariyal had 'high' confidence in the content knowledge, pedagogical knowledge, pedagogical approaches she could adopt in teaching English, and use of technology for pedagogical benefits. Fariyal's perception of her ability to learn and keep up with new technologies, solve technical problems, research, and use different applications specifically created to teach English was also high. A summary of how she rated herself on her familiarity and using some of the commonly available technologies is shown in Table 5.13.

Table 5.13 *Fariyal’s familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	4	4
Assessment software. e.g., Online quizzes/ Tests	4	3
Collaborative software. e.g., Wikis, Google drive, Padlet	4	2

Multimedia creation software. e.g., Desktop publishing, Photoshop	3	3
Discussion forums/boards. e.g., on Moodle, Blackboard	3	2
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	3	1
Blogging apps. e.g., Weebly, WordPress, Tumblr	3	1
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	4	4
Tablet or iPad-based applications	4	4
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	3	3
Virtual classrooms	4	3
Adaptive Learning Platforms	4	3

Although Fariyal seems to be highly familiar with many of the technologies, the most frequently used technologies (one or more times a week) in her teaching were 'presentation software', 'interactive boards', and tablets. The following section explores how Fariyal adopted some of these technologies in her teaching.

Implementation of technology in classroom teaching

Fariyal mentioned that she used the knowledge she acquired from Google Classroom training to record and share student marks with school management. She discovered that sharing materials via Google Classroom was simpler and saved her time, and therefore believed it was very much needed in her work. She also agreed that Google Classroom has several other functions. However, she did not use them since she was "not that well versed" with it, and also because the tablet implementation program was halted and "[teachers] do not use" it anymore.

Therefore, Fariyal's use of technology was not different from the other participants. That is, she mainly incorporated PowerPoint presentations and videos in her lessons. For example, when teaching grammar, verbs, adverbs, she used to show PowerPoint presentations or YouTube videos to students. *Figure 5.11* shows an example of a PowerPoint presentation and a game activity she conducted to teach "subject-verb agreement". Rather than her verbally explaining, she believed showing videos helped students understand easily and rendered the lesson "less boring". In her opinion, these media (PowerPoints, videos) allowed to acquaint students with things "they might not have seen [...] previously".

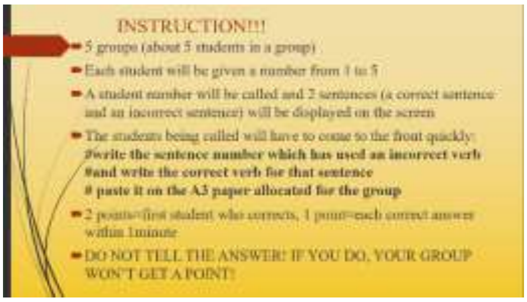


Figure 5.11 Example of a PowerPoint presentation Fariyal used to teach "subject-verb agreement" and then conduct an interactive game with her students.

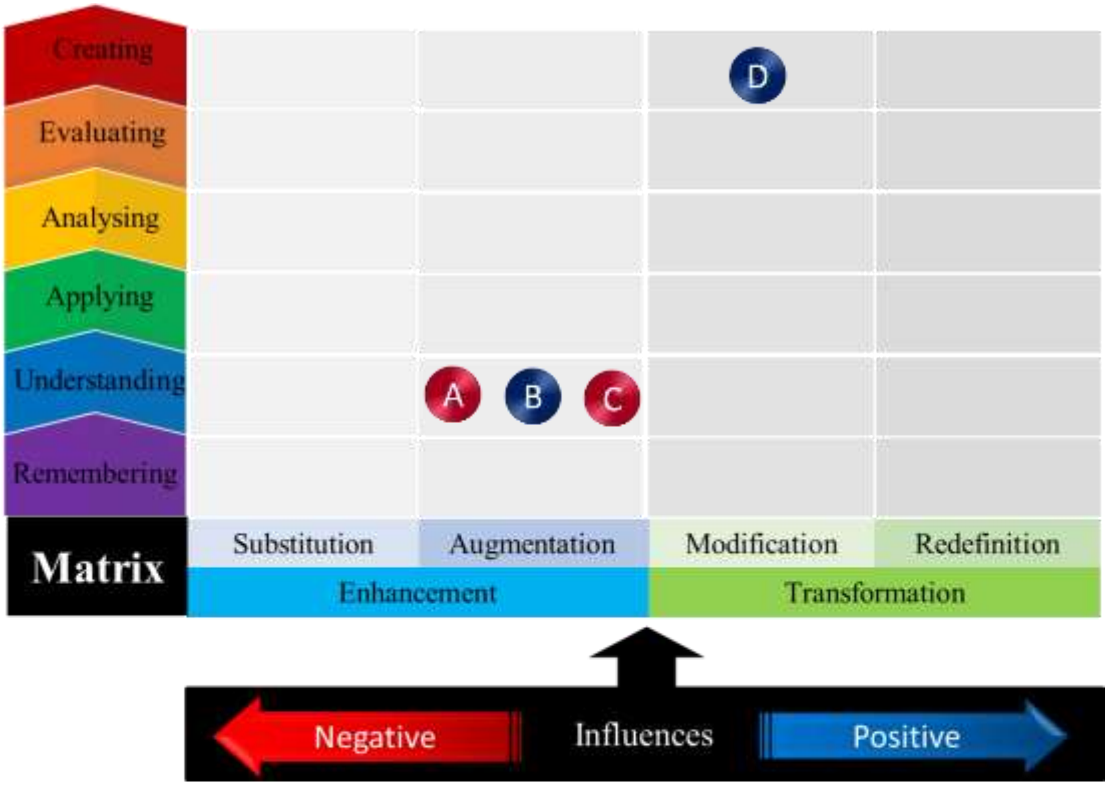
Furthermore, being an English Language teacher, it was essential to develop and improve students' listening, writing, and speaking skills. For listening activities, she used the CDs given by her school. Typically, the audio-visual room or the labs (e.g., computing or science lab) were used to conduct listening activities since those rooms had the requisite equipment (e.g., computer, speaker system, projectors, and internet connection). Similarly, to improve students' speaking and writing skills, she had students develop group presentations based on real-life scenarios.

> we did a lesson on [the new bridge] the activities held on [the bridge], [and] how [the bridge] is helpful to them (Fariyal)

In this activity, she required the students to use images and videos to create a PowerPoint presentation of their experiences and reflections about the "new bridge" built between the two cities and present their work to the class. Fariyal claimed that these strategies helped develop students' writing and speaking skills in a "practical way… [by] applying" their knowledge and understanding creatively.

Impact of technology use on teaching and learning

A summary of Fariyal's implementation of technologies and the perceived impact on student's cognitive engagement is depicted in *Figure 5.12*.



Key: A - PowerPoint presentations, YouTube videos to explain (teachers)
B - Online quiz via Google Classroom (student)
C - Google Classroom to share materials (teachers)
D - Create PowerPoint presentations (students)

Figure 5.12 Two-dimensional matrix to visualise Fariyal's technology implementation and the perceived impact on student's cognitive engagement

Fariyal's use of Google Classroom to share student marks with school management made it simpler and saved her time. Also, her use of PowerPoint presentations and videos helped students understand easily and made the lesson less boring for them. The videos also helped to quickly acquaint students with things they might not have seen previously. Thus, these digital technologies enhanced the teaching and learning activity but did not significantly shift the learning outcome. However, students' collaborating to create PowerPoint presentations (e.g., about the new bridge) helped deepen their understanding, encouraged creativity, and engaged them at higher cognitive levels, thus transforming student learning. Such activities helped modify teaching and learning activities, resulting in major pedagogical shifts in the learning task (Puentedura, 2012).

Influences that impacted teachers' technology implementation

One primary influence that positively impacted Fariyal's integration of technology in teaching was the availability of resources and facilities (e.g., projector, internet, desktop computers, CDs, speaker system, computer lab) at her school. She believed that the school management supported teachers by making technology accessible for them to use in their classrooms. She further highlighted their assistance in managing shared resources and attempting to solve the technical problems teachers face.

Fariyal, however, felt that there was "too much [emphasis on] technology," and she was "forced to use" it in her teaching, especially during the early days when the school began introducing computers inside the classroom. As she previously mentioned, her perceived lack of experience might explain this pessimistic view. Another reason might be the distress induced due to technical glitches or device failure. One incident she shared was when she prepared to conduct the lesson using "the projector, [but due to technical] ...problems", she could not use it. This caused her a great deal of distress, mainly when she could not conduct the lesson as planned due to technical problems beyond her control. Thus, these unexpected technical problems and device failures were additional barriers to Fariyal's technology integration efforts.

The above issues were further exacerbated due to the limited knowledge and experience she has had with technology. According to Fariyal, despite having done technology-related trainings, she felt that it was not sufficient for her to apply the skills in her teaching. She felt that the online training mode, the lack of practical (hands-on) experience, and the time allocated for the training were insufficient for her to learn to integrate technology in her lessons. Thus, she believed that the way training was carried (online) out needed to change. She preferred more practical-oriented sessions to observe how technology can be practically used in the class and preferred training that had adequate time duration and is continuous.

5.10 TEACHER 7 – SHIDHATHA (SCHOOL C)

Shidhatha, a 40-year-old, has been working in the teaching profession for more than 15 years. She has taught Chemistry and Biology in many different schools in the Maldives, but predominately at School C. At the time of the study, she was teaching Chemistry to Year Nine students. Shidhatha received her teacher training at Sri Lanka's National Institute of Education and has a Master's Degree in Education Administration.

Shidhatha's interview data suggested that her school management, especially the principal, has been very supportive in encouraging teachers to make maximum use of the technology resources available at the school. Inspired by the principal's support, Shidhatha and many other teachers had even purchased laptops, which they used for teaching purposes. She also recognised the school's efforts to train teachers to keep them abreast with the knowledge and better leverage its resources (e.g., the virtual learning management system (VLMS) implemented at the school). However, Shidhatha attributed most of her technological skills to research and self-learning (e.g., Googling, watching YouTube videos) and sometimes seeking guidance from her colleagues. She also acknowledged some of the knowledge and skills she had acquired (e.g., Google Classroom) to the Ministry of Education. Shidhatha felt that this training was beneficial because it helped her develop the skills and abilities to integrate technology in her lessons. Shidhatha's responses to the TPACK perception survey are shown in Table 5.14.

Table 5.14 *TPACK survey results for Shidhatha*

TK	CK	PK	PCK	TCK	TPK	TPACK
3.7	4.0	4.0	2.5	2.7	3.5	4.0

The above results indicate that Shidhatha had a 'high' perception of most of the knowledge constructs, including high confidence and in-depth understanding of the contents of her subject and appropriate pedagogical strategies to create challenging learning activities. The 'high' scores for TK and TPK show her enthusiasm to learn and keep up with new technologies and combine technology for pedagogical gains (e.g., facilitate students' use of technology to research and explore real-world scenarios collaboratively). Interestingly, like Lirgam and Anil, the lower scores on PCK show lower confidence in using appropriate teaching strategies to help students grasp the content in Chemistry and guide their learning. Similarly, the low score on technological content knowledge symbolizes less confidence in researching and adopting different technology applications specific to her subject.

Nonetheless, the survey results showed that Shidhatha frequently used technology in the classroom (at least once a week). Below is a summary of how she ranked herself regarding familiarity and use of some commonly available technology.

Table 5.15 *Shidhatha's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	5	4
Assessment software. e.g., Online quizzes/ Tests	5	4
Collaborative software. e.g., Wikis, Google drive, Padlet	5	4
Multimedia creation software. e.g., Desktop publishing, Photoshop	3	2
Discussion forums/boards. e.g., on Moodle, Blackboard	5	3
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	3	3

Blogging apps. e.g., Weebly, WordPress, Tumblr	5	4
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	2
Tablet or iPad-based applications	3	4
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	3	2
Virtual classrooms	4	4
Adaptive Learning Platforms	3	2

According to the above figures (see Table 5.15), Shidhatha had 'very high' or 'high' familiarity with 'presentation software', 'assessment software', 'collaborative software', 'discussion forums', 'blogging apps', and 'virtual classrooms', and frequently (one or more times a week) used these technologies for teaching, except for 'discussion forums'. How Shidhatha applied these technologies in her classrooms was explored during the interviews and is presented next.

Implementation of technology in classroom teaching

Shidhatha considered herself a moderate user of technology in her classroom teaching. Her interview data revealed that Shidhatha’s use of technology was no different from the previous participants. She essentially shows PowerPoint presentations and YouTube videos using the Smart TV inside the classroom to conduct lessons. She struggled, though, because all the classrooms did not have televisions. When asked about the tablets, she informed that she seldom used them when conducting lessons but used them to share resources.

Perhaps, one unique highlight from Shidhatha's interview was her use of the virtual learning management system (VLMS) implemented at her school. She claimed that she used the VLMS for both administrative tasks (e.g., sharing materials such as lesson plans and student assessment marks with the management team) and to conduct instructional activities (e.g., online lessons and assessment activities). As an example, she shared her experience of assigning differentiated assessment activities to students via the VLMS. In creating the online assessment activities, she used to include simple questions "for the [low ability] students so that they [could] do it without difficulty [and give] … very challenging type questions" for the higher ability students. In her view, the VLMS allowed her to differentiate the tasks based on students' ability levels easily. She mentioned that the VLMS was also used to administer "MCQ [sections of school-based] exams of grades 8, 9, and 10." She stated that via the VLMS, students could complete "the MCQ papers online [using] their tablets". Shidhatha found this immensely beneficial for both students and teachers as it "immediately [provided] the result" and saved her much marking time.

Furthermore, as a chemistry teacher, Shidhatha understood the importance of conducting experiments and practical work to provide authentic learning experiences. However, due to limited lab resources, she faced challenges conducting actual experiments. Thus, she mentioned using YouTube videos and an online website to demonstrate experiments.

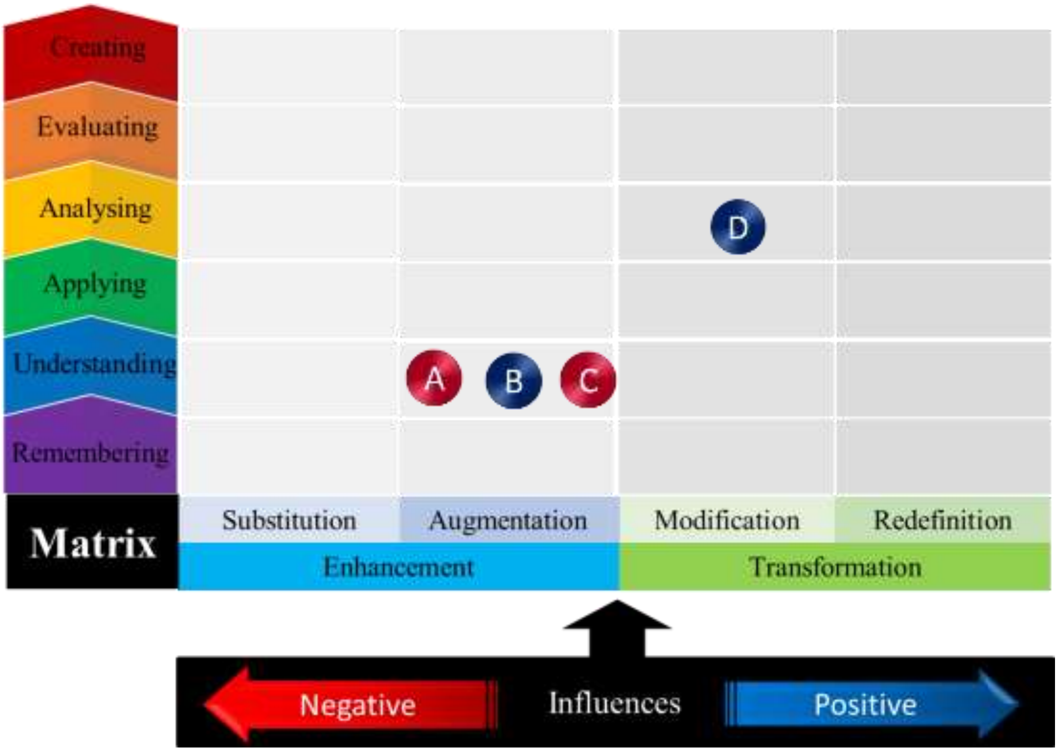
> We do not have so many chemicals, and we cannot do experiments. So, I show experiments from YouTube, or we have a virtual lab … I use a programme like a virtual lab so that students can do once again … this virtual lab, is it something that I identified myself … and use that to demo to students while teaching (Shidhatha)

Though she could not recall the website, she considered it useful because it enabled her to simulate experimental conditions that yielded authentic results, almost like conducting experiments with actual laboratory equipment and allowed students to see the outcome by varying different parameters. The fact that it was online meant that students could practice the experiments repeatedly. This, she supposed, was incredibly helpful, given that actual experiments were not possible at the school due to resource constraints.

Impact of technology use on teaching and learning

Figure 5.13 summarizes Shidhatha’s integration of digital technologies and the perceived impact on student’s cognitive engagement. As seen from the figure, Shidhatha's use of technology (e.g., PowerPoint presentation, YouTube videos, online MCQ quiz) enhanced the teaching and learning tasks. It aided her to easily demonstrate experiments, assess and help students understand the topic easily. Meaning, the PowerPoint presentations, and videos augmented the activity by allowing students to quickly revisit essential parts of the lesson by switching back and forth. Likewise, the online quiz saved time (spent on marking) and allowed her and the students to view results immediately, suggesting some functional improvement on the task. However, it did not alter or change the learning activity or the outcome but only had minimal impact on students' cognitive engagement (remembering and understanding).

Using virtual lab, in contrast, required higher cognitive engagement (analysing) from students as they had to apply their knowledge to analyse the different input variables and see the resulting outcomes, thus transforming their learning. It helped modify the learning task and resulted in major pedagogical shifts in their learning, which would not have been possible without technology.



Key: A - PowerPoint presentations, YouTube videos for explanation (teachers)
B - Interactive online quiz on VLMS (student)
C - Share materials (via VLMS) (teachers)
D - Virtual lab experiments (students)

Figure 5.13 Two-dimensional matrix to visualise Shidhatha's technology implementation the perceived impact on student's cognitive engagement

Influences that impacted teachers' technology implementation

From Shidhatha's interview, it was evident that the support she received from the school management, especially the principal (e.g., making resources available, having a staff designated to assist teachers with technical issues), had a significant influence on her motivation to make maximum use of the technology resources. Additionally, her beliefs about the benefits of technology in teaching and learning (e.g., easy to explain using PowerPoint presentations, videos, enhance students understanding, easily access online resources such as the virtual lab and practice multiple times, save much marking time, and get immediate results for assessments) also contributed to her adoption of technologies. Further, her technological skills, the desire to learn from her research, and how easy it was for her to learn and adopt technology were also critical factors for Shidhatha.

Shidhatha stated that although the school had a computer lab and an AV room, she could not use those resources, as it required pre-booking, and most of the time was reserved by other teachers. Thus, the availability of technological tools and facilities at her school affected

Shidhatha's technology integration efforts. While discussing the resources, she declared that the lack of an internet connection was a significant impediment to her using technology in class. As a result, despite the positively held beliefs on the benefits of technology for teaching and learning, she claimed that she could not use it adequately in her classrooms. Lastly, Shidhatha shared the challenges she occasionally faced due to student behaviour, especially while using tablets, when "[student] get overexcited sometimes [making] it difficult" for her to manage the classroom. She claimed that she had to spend time attending to behavioural issues instead of conducting the lesson and thus, preferred to avoid using tablets.

5.11 TEACHER 8 – AANISA (SCHOOL C)

Aanisa, 32, has a Bachelor's Degree in Arts and Economics from India and completed her teacher training at the Maldives National University. She has had more than nine years of teaching experience working across several schools within the Maldives. At the time of the study, she was completing her seventh year at this school, teaching Economics to students in Years Nine and Ten.

According to Aanisa, students' improved academic achievement in Economics over the past seven years was due to the combined effort from her department and the support they received from their school principal. Aanisa's strive to put maximum effort into her work was partly due to her principal, who requested her to work "together [with the school to] improve the results". Like Shidhatha, Aanisa also highly regarded the support she received from the school administration, especially the principal, and his efforts to provide teachers with resources (e.g., VLMS, laptops, internet access). For instance, she claimed that the VLMS, which the teachers considered very useful, became a reality only because of the principal's strong technology leadership and foresight. Moreover, to ensure the project's success, Aanisa stated that the principal employed a full-time IT technician at the school, whose role was to support and help teachers with technical issues (e.g., when using the VLMS). Thus, Aanisa characterised the principal as a leader who empowered teachers to go beyond the expected norm, which motivated some to buy "their own personal laptop" to use in their classrooms. Aanisa believed that this helped to reduce teacher reliance on the school for computers, resolving, to some extent, the issue of "unavailability" of technology resources.

Moreover, Aanisa stated that professional development training, particularly on using the VLMS, was given to teachers to assist them in delivering more technology-based lessons, and the principal himself conducted some of these. According to Aanisa, the training taught her to create online quizzes and assessments and upload and share resources on the VLMS. However, given that technology keeps evolving continuously, Aanisa felt that training should be conducted regularly, and to keep abreast and harness technologies in her teaching, she mostly did self-study and sometimes sought assistance from more competent colleagues. The survey data shows that Aanisa has been using technologies frequently (one or more times a week) in her lessons. Table 5.16 shows her perception of the knowledge areas of the TPACK framework.

Table 5.16 *TPACK survey results for Aanisa*

TK	CK	PK	PCK	TCK	TPK	TPACK
4.3	4.7	4.2	5.0	4.7	4.3	4.0

As evident from the above table, Aanisa demonstrated a perception of all the TPACK knowledge constructs. This suggests that she has an in-depth knowledge of her subject and can use various pedagogical strategies to guide student learning. Likewise, she seemed to be confident in her ability to research and learn about different technology applications specific to her subject and combine them for pedagogical benefits. Table 5.17 below shows Aanisa's self-rating on her familiarity and use of some commonly available technologies.

Table 5.17 *Aanisa's familiarity and use of technologies*

Technologies	Familiarity	Use
Presentation software. e.g., PowerPoint/ Prezi	5	5
Assessment software. e.g., Online quizzes/ Tests	5	4
Collaborative software. e.g., Wikis, Google drive, Padlet	3	2
Multimedia creation software. e.g., Desktop publishing, Photoshop	2	3
Discussion forums/boards. e.g., on Moodle, Blackboard	3	2
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	4	4
Blogging apps. e.g., Weebly, WordPress, Tumblr	5	4
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	2
Tablet or iPad-based applications	4	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	3	3
Virtual classrooms	4	3
Adaptive Learning Platforms	2	3

The above table shows that although Aanisa has 'very high' familiarity with 'presentation software', 'assessment software', and 'blogging apps', she mostly adopted 'presentation software' in her teaching. The analysis of the interview data presented below further explores these results to get insight into her adoption of these technologies in teaching.

Implementation of technology in classroom teaching

In Aanisa's view, "economics [was] not an easy subject" for many students. Her philosophy, however, was that if taught effectively, it can be easy to inspire and improve student performance. Thus, "to [make] it easy for the kids", she sought to integrate as many authentic learning experiences as possible into her lessons. For example, she talked about the project she assigned to students on the topic "economic activities of small firms". The project required students to visit the "small businesses in [the] local area" on their island, conduct interviews to gather "information from different shops [about the] things they do to make them stay in business without shutting down". Students were expected to compile the findings digitally, and then discuss their work in the class. Aanisa discovered that encouraging students to investigate problems themselves, instead of explaining them on a PowerPoint presentation was more beneficial, as it motivated students and enhanced their engagement. She further argued that, utilizing technology's affordances to give authentic learning experiences that required students to actively construct knowledge and skills showed remarkable "improvement in [student] results", which she witnessed from their performance in the various assessment activities.

According to Aanisa, providing students the opportunity to research and learn themselves using online sources was a huge driver of the dialogue in her classes. The peer teaching activities she conducted in her classes were a good example of such activities. She usually had students "who [were] very familiar with the topic" conduct research, "make some presentation," and then teach the class "either in groups or as individuals". She believed that engaging students in these types of activities had many advantages. For instance, it allowed students to develop their research skills (e.g., explore different sources to gather relevant information on the topic) and develop their presentation skills (e.g., create presentations and teach the class). Besides, she found that "instead of the teacher teaching" all the time, encouraging students to "speak together and learn from each other" helped students, especially the "slow learners," to grasp the concepts easily. She also believed this provided an impetus for peers who teach to "revise and deepen their understanding and prepare for their exams".

In Aanisa's opinion, allowing students to research and prepare in advance aided to develop their critical thinking skills and the capacity to "counterattack whatever concept or information that [she] shared with them". For Aanisa, these activities were "quite enjoyable", as they encouraged students to "gather information" to challenge the teacher and thereby helped them learn interactively.

Aanisa also considered digital technologies instrumental in designing lessons that address diverse student needs. For example, she incorporated multimedia (e.g., images, videos) in her lessons since she believed that it helped students, especially the "visual [and] slow learners," to grasp concepts better as opposed to them "[simply] listening to a lecture". Furthermore, she asserted that, by using digital technologies (e.g., PowerPoints), she could break down "huge descriptions [into] short[er] sentences". Aanisa presumed this strategy was beneficial for slow learners who struggled to comprehend complex concepts. Consequently, she reasoned that using technology (e.g., multimedia presentations) rendered the explanations easier for the teacher while enhancing student understanding and maintaining their motivation in the lesson.

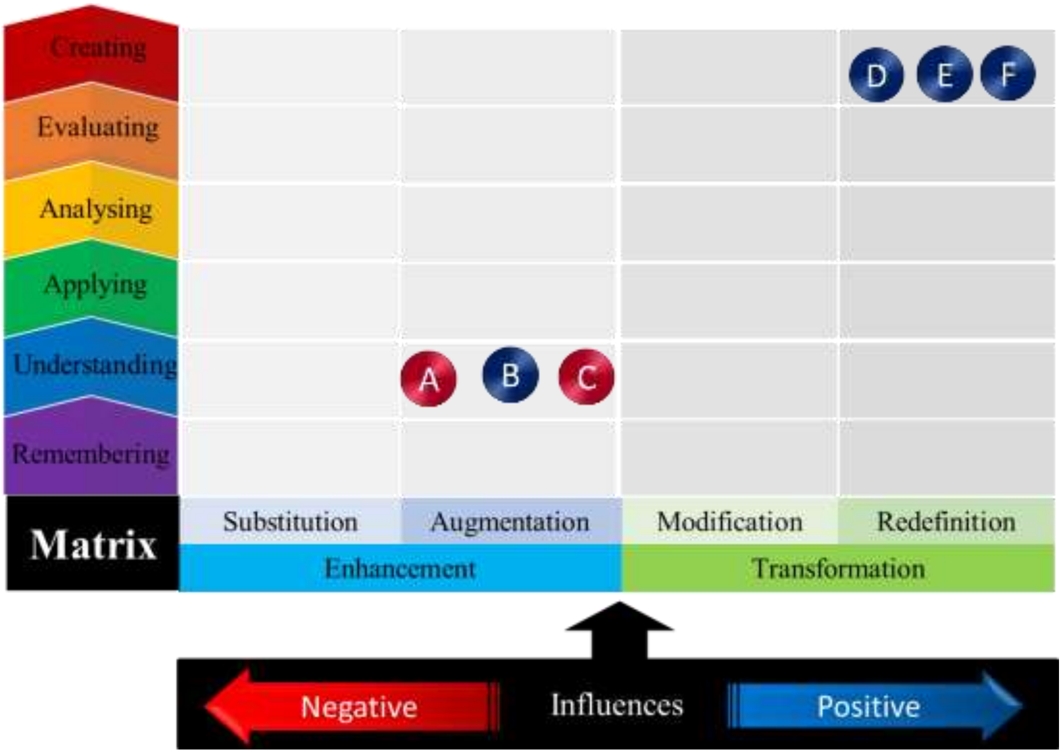
Another digital technology Aanisa talked about was the VLMS at her school. Like her colleague Shidhatha, Aanisa also used the VLMS typically for administrative and academic purposes (e.g., share lesson plans, students' marks, report book comments with school management, and share materials and assessments with students). She believed that the VLMS had several benefits for the whole school community. For instance, it gave a platform for teachers to share learning activities online (e.g., MCQ quizzes, "fill in the blank" type questions), enabling her to assess and monitor student learning more efficiently.

In Aanisa's view, the VLMS benefited students too. Students could "access [online activities] and practice multiple times, [at their leisure], and prepare for their exams" conveniently without the need for face-to-face "contact between teacher and the student". Aanisa viewed this as a great help, especially for "the slow learners", who required repeated practice to master their learning "in a simpler way", which was afforded through this technology. She further noted that with the VLMS, students could readily "access [the] information made available [on the website]" at any time, at their convenience. To elaborate, she explained that via the VLMS, students could find out the work assigned to the class even if they missed the lesson and easily retrieve materials they might have lost.

Lastly, Aanisa proclaimed that the VLMS was beneficial not only to the teachers and students but also to the parents. She alleged that with the VLMS, opportunities now existed for parents to access the online system using "their own login" at any time of the academic year and track their child's progress.

Impact of technology use on teaching and learning

How Aanisa implemented digital technologies and the perceived impact on student's cognitive engagement is summarized in *Figure 5.14.*



Key: A - PowerPoint presentations, videos (teachers)
B - Interactive online quiz (student)
C - Share materials (via VLMS) (teachers)
D - Research activities, multimedia presentations (students)
E – Peer teaching activities (students)
F – Project-based learning activities (students)

Figure 5.14 Two-dimensional matrix to visualise Aanisa's technology implementation and the perceived impact on student's cognitive engagement

As seen from *Figure 5.14* above, Aanisa's use of technology (e.g., PowerPoints images, videos) in her lessons and sharing these on the VLMS helped students, especially the visual and slow learners, to understand the lesson, resulting in learning enhancement for students (Puentedura, 2012). The use of PowerPoint presentations, videos, images, and shorter sentences all augmented a standard presentation with some functional improvement in the learning task. For example, ease for visual/ slow learners; revisit important content/ points easily by switching back and forth between slides/ scenes; easily access and revise at students' convenience; view the work even if they were absent or lose their notes. Likewise, the online assessments (MCQ quizzes, fill in the blanks) also served as a substitute for paper-based quizzes, with some functional improvements (e.g., attempt multiple times, control progression in the quiz, and know the correct answer immediately) with no changes to the immediate learning outcome. The same learning outcome could have been achieved without using the technology (Puentedura, 2012). Thus, the use of technology in this way required less cognitive engagement from students. This implies that the thinking skills required from students were at the lower level of Bloom's taxonomy, where it helped foster their remembering and understanding skills (Beauchamp et al., 2015; Keane et al., 2016; Patton, 2015).

Whereas, the students' use of technologies to actively construct knowledge and skills (e.g., conduct research, project work, peer to peer teaching) engaged them in higher-order thinking skills (analysing, evaluating, creating), (Churches, 2008). Consequently, this helped students develop the key competency skills (critical thinking, creativity, use technology, and media) (Gebre et al., 2014) as prescribed in the Maldivian national curriculum framework (NIE, 2014). These activities resulted in major pedagogical shifts where the teaching and learning activities were redefined as technology created avenues for students to carry out learning activities in entirely new ways (Puentedura, 2012). These strategies effectively promoted authentic, collaborative learning and helped students revise and prepare for their exams in ways previously inconceivable (Puentedura, 2012). The learning activity was transformed using a range of multimedia where students collect, communicate and disseminate their work (Puentedura, 2012).

Influences that impacted teachers' technology implementation

Like other, a multitude of factors influenced Aanisa's adoption of technology. To teach any given topic, she first considered the lesson objectives, the benefit of using technology, the availability, and the condition of the technology resource. For instance, if the topic she planned to teach was very unfamiliar to students, she might want to show a YouTube video to help them understand it easily. Nevertheless, the lack of internet access inside the classroom prevented her from accessing the video online during the lesson. However, if she thought the video was critical for the lesson, she used to "stream" it from the staffroom and show it in the class; or direct students to "access the resource [video]" from home. Another concern was the lack of resources or applications (e.g., articles and online activity) relevant to the topic and the high subscription fees for online resources. Hence, despite knowing the value of the resource and having the skills to utilise it for learning gains, she could not adopt it into her classes. In contrast, there were instances where the school provided the technology resource, but teachers' lack of knowledge and experience inhibited them from effectively incorporating it in their teaching.

The (un)willingness of parents, especially those that believed in traditional teaching methods, was another concern for Aanisa. Somehow, she felt that some parents considered technology a threat, mainly due to the fear associated with cyber-bullying, antisocial behaviour, and inappropriate content their children could get exposed to with technologies (e.g., internet, mobile devices). Thus, even though parents understood the potential of educational technologies, some parents considered technology a "threat" and believed that the "traditional way of teaching" was safer than using technology. This implies the importance of creating awareness and training parents for their buy-in, especially when introducing new technologies (e.g., tablets) to students. Thus, to reduce parental fear and bring them closer to school and their children's work, it expanded the access parents had to the school. For instance, parents were given access to login into VLMS to view their children's work anytime (e.g., report cards and other information, assessment work, their achievements, etc.). Allowing access to parents, she believed, created some sense of security for them about their children's work and how they progress. This offered parents the opportunity to support their children with the schoolwork and build closer contact between the parent and the school community.

5.12 TEACHER 9 - RAIHANA (SCHOOL C)

Raihana, 36, taught Mathematics to year Nine students at this school. At the time of this study, she was completing her ninth year as a Mathematics teacher. She has obtained a Diploma in teaching Mathematics and a Bachelor's Degree in Education. The quantitative survey indicated that Raihana's perception of the TPACK constructs was 'average', as shown below.

Table 5.18 *TPACK survey results for Raihana*

TK	CK	PK	PCK	TCK	TPK	TPACK
3.5	4.0	4.0	4.0	3.3	4.0	3.3

The figures in Table 5.18 show that Raihana perceived highly on her subject and pedagogical knowledge. It also demonstrates that she had high confidence in her ability to combine technology for pedagogical benefits. Nevertheless, she was less confident in using software explicitly created for Mathematics or adopting technology to teach her subject's contents using various pedagogical strategies. A possible reason could be the lack of freely available content for use with technology to teach Mathematics. The survey data further indicated that Raihana frequently used technology (one or more times a week) in her classroom teaching. Table 5.19 below summarizes the self-rated scores on her familiarity and use of some of the digital technologies.

Table 5.19 *Raihana's familiarity and use of technologies*

Technologies	**Familiarity**	**Use**
Presentation software. e.g., PowerPoint/ Prezi	5	5
Assessment software. e.g., Online quizzes/ Tests	4	3
Collaborative software. e.g., Wikis, Google drive, Padlet	3	1
Multimedia creation software. e.g., Desktop publishing, Photoshop	3	1
Discussion forums/boards. e.g., on Moodle, Blackboard	4	1
Web-based social media platforms. e.g., Facebook, YouTube, Instagram	3	1
Blogging apps. e.g., Weebly, WordPress, Tumblr	4	3
Interactive boards. e.g., Smart board, Interactive whiteboard (IWB)	3	2
Tablet or iPad-based applications	3	3
Cloud-based apps. e.g., Dropbox, Gmail, Facebook	2	1
Virtual classrooms	4	3
Adaptive Learning Platforms	2	1

The above figures demonstrate that Raihana was highly familiar with 'presentation software' and regularly used it in her teaching. It also shows that, although she was familiar with assessment software, discussion forums, blogging, and virtual classrooms, she rarely used them in her teaching. These results are explored further in the following paragraphs.

Raihana declared that she was very "unfriendly with [technology and was] never a self-learner", suggesting a low self-efficacy towards technology. This finding is supported by the quantitative results shown above (see Table 5.18), which shows that she had a lower perception of technology and its related knowledge domains. Upon further inquiry, it was identified that this was related to her beliefs about using technology to teach her subject. According to Raihana, the IGCE Mathematics was very exam-oriented, and therefore she did not believe that using technology was the most effective way to teach the subject to achieve the desired outcome (high grades in the exams), which also explains the less frequent use of digital technologies in her teaching.

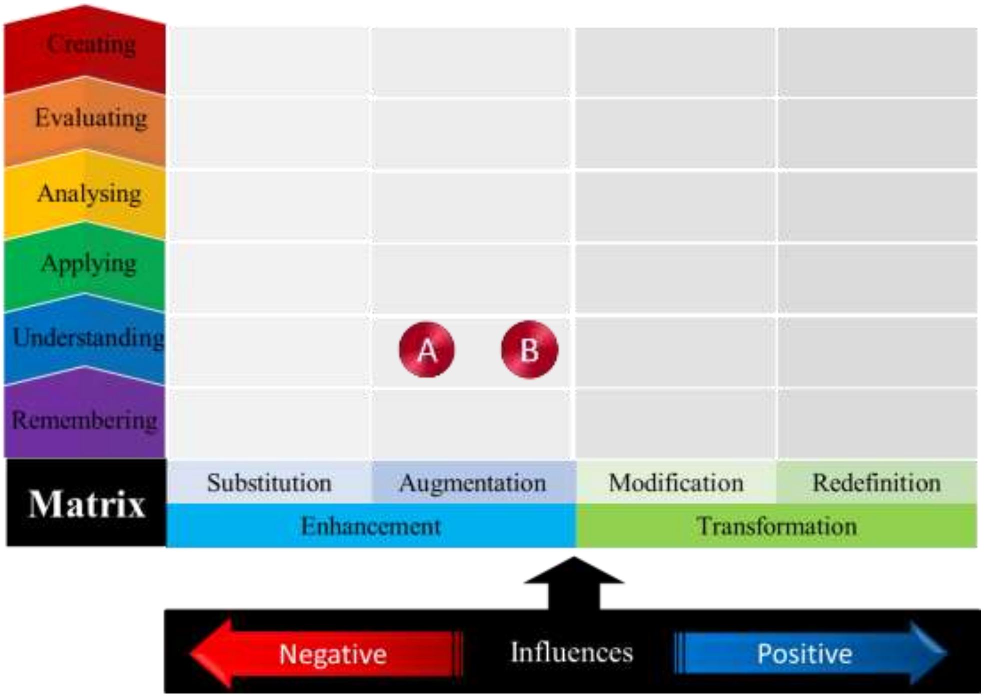
Another reason for her low technology self-efficacy could be associated with the technology training she had undergone. Raihana recollected some of the training she did during the bachelor's degree programme, where she acquired skills to create "short quizzes, some audio and video clips". These skills were further reinforced from the various professional development sessions she did at her school. She believed that this training helped her learn how to use the VLMS to create and "upload quizzes, share students' assignments … upload the marks and comments, [and prepare] the report book". In addition, she talked about the online training she did on the Google Classroom, which the Ministry of Education conducted. In her view, this training (e.g., Google Classroom) was "very short notice", and the time allocated for her to complete and "submit [the tasks was] inadequate". Consequently, Raihana declared that she had "forgotten most of the things" she learned from the training. Thus, she believed that she still lacked sufficient knowledge and skills and needed more training to integrate technology in her lessons. This could perhaps explain the low TPACK scores, and the lower use of many technologies mentioned in Table 5.19. Thus, Raihana claimed that if she wanted to "do some work [using technology, she often sought] help from [either] the school ICT teacher or one of [her] friends".

Implementation of technology in classroom teaching

According to Raihana, her lessons usually had three main activities: explaining the main points of the lessons, demonstrations of few examples, and students working out a set of questions to reinforce learning. Thus, in a typical lesson, she would use a PowerPoint presentation projected onto the Smart TV in the classroom to facilitate her explanation of the topic. This would then be followed by demonstrating few examples of how to solve the math problems either on the whiteboard or by showing videos and then getting students to solve problems on the worksheet she assigned. Her justification for using this media (e.g., PowerPoint presentation, video) was that it made it easier for her to explain and also helped students to "visualize [and] understand concepts easily [within] less time". Besides, she found that students became "more curious, … enjoyed [the lesson and] remember[ed] the knowledge easily" when technology was used. However, Raihana used these technologies only if it was available in the class, because according to her and the other participants from this school, (see Sections 5.10 and 5.11), the Smart TV was not working in some classes, and the internet was not accessible in any class. In addition, Raihana mentioned using the VLMS at her school, but mainly to share work with students (e.g., assignments) and the school management (e.g., lesson plans, student report cards).

Impact of technology use on teaching and learning

Figure 5.15 summarizes how Raihana integrated digital technology and the perceived impact on student's cognitive engagement.



Key: A - PowerPoint presentations, videos (teachers)
B - Share materials (via VLMS) (teachers)

Figure 5.15 Two-dimensional matrix to visualise Raihana's technology implementation and the perceived impact on student's cognitive engagement

As seen from *Figure 5.15* above, the use of PowerPoint presentations and videos led to some functional improvement in the tasks (e.g., easy for learners to understand, revisit important content/ points easily by switching back and forth between slides/ scenes), and therefore enhanced the teaching and learning activity in Raihana's class. There were no changes to the immediate learning outcome. The same learning outcome could have been achieved without using the technology (Puentedura, 2012). Moreover, the technology used to show presentations or videos engaged students in lower-level thinking skills, perhaps with them remembering or understanding, and therefore less cognitive engagement (Beauchamp et al., 2015; Keane et al., 2016; Patton, 2015).

Influences that impacted teachers' technology implementation

In describing the factors that influenced Rachana's implementation of technology in her lessons, a significant contributing factor she talked about was the encouragement she received from the school management, especially the principal. According to Raihana, the principal's enthusiasm for integrating technology was the reason for the success of the VLMS at her school. She was proud of this remarkable achievement, especially considering the school being a small community school on a local island. Thus, Raihana described her principal as a strong visionary leader who wanted the school to advance its technology adoption. Moreover, to ensure that teachers were comfortable using the VLMS, she mentioned that the principal personally conducted training and assisted whenever teachers needed help to solve problems, which motivated her to adopt technology to a certain extent.

Furthermore, the interview findings revealed that although Raihana understood the benefits of using technology for teaching and learning, the lack of resources in all the classrooms (e.g., Smart TV was not working, and the internet was not accessible) was a hindrance to her technology integration endeavours. Besides, her low self-efficacy and negative views about her technology competency played a significant role in her technology adoption decisions. The findings show that Raihana was not comfortable adopting technology, nor was she motivated to do self-learning. As a result, some of the training (e.g., Google Classroom) she had undergone was not of much help. She believed that they were too short notice and the time allocated was not sufficient for her to complete all the training activities. Thus, she claimed that she still lacked sufficient knowledge and skills and needed more training to integrate technology in her lessons.

Besides, Raihana viewed technology as inappropriate for teaching Mathematics and believed that the time allocated to cover the syllabus was insufficient, especially if she were to use technology. She said:

> [We have] so much to cover in the syllabus ... this year this [much content] should be covered. So, time is a problem for us. If we use technology, it is more time-consuming. [The] things which we plan for 35 minutes may take [more time] … [and using] technology means … so many other issues … unable to switch on a device [due to] battery or charger failure, network issues, [no] Wi-Fi if we want to load some video … it can be very slow (Raihana)

As seen from the above quote, Raihan's primary focus was on covering the syllabus. This type of thinking is perhaps associated with how her success as a teacher will be assessed. In the Maldivian education system, the performance of teachers and schools is based on students' academic performance. Thus, more focus is on yielding high results than on developing skilful citizens. Similar views were observed from Malik's interview, who also taught Mathematics (see Section 5.5). Another concern evident from Raihana's quote above was related to the unanticipated technical problems and her inability to solve them, which impeded her lessons. This caused her a great deal of frustration and dismay. Consequently, Raihana believed that the time allocated for each lesson (35 minutes for a session) was not enough to adopt technology in her lessons. She found that necessary lesson time was lost trying to solve unanticipated technical issues (e.g., battery or charger failure, unable to switch on a device, no wi-fi, slow internet speed) or due to the slow interpret speed that takes a long time to open a video or a quiz that she wanted to show students.

Another factor that became a problem for Raihana was the negative effect technology (innovative technologies such as tablets) had on students. For her, the tablets became a source of distraction because on days when she planned to conduct activities using tablets, students forgot to take them to school, and also when they did have tablets, she faced many classrooms management issues because students got too excited and went off-task (play games with it instead of doing the activities she assigned).

> I tried once, and that day there was chaos in the class … like, they were playing games, so many new things they wanted to try. So, the things … the quiz I wanted, I was not able to conduct …. students were so excited that they wanted to enjoy some other thing [with tablets]. They wanted to share so many other things (Raihana)

Raihana struggled to get students to focus on the learning task because they were keener to explore and play games with the device instead of following her instructions. As Nikolopoulou (2020) explained, this phenomenon was mainly because, with new innovative technologies such as tablets, there can be a considerable shift in the dynamics of students' social interactions and attention. That is, tablets had been a device they usually used for gaming, and thus, the transition of its use from gaming to learning was hard for the students. Thus, she could not carry out the activities she planned for the lesson and therefore did not feel comfortable using tablets in her classes. Hence, all these factors negatively influenced her adoption of technology in teaching and learning.

5.13 CHAPTER SUMMARY

This chapter presented and analysed the data (semi-structured interview and document artefacts) gathered during phase two to investigate how Maldivian in-service secondary grade (grades 9 and 10) teachers implemented digital technology in their lessons. The aim was to address research question two: how teachers integrate digital technology and how it impacts students' cognitive engagement (*RQ2*); and research question three: what factors influence teachers' technology integration efforts (*RQ3*). A brief overview of the school contexts was provided in Section 5.2, followed by Section 5.3, a reiteration of the base model used to conceptualize (a) how teachers implemented technology in their classroom teaching and the perceived impact on student's cognitive engagement, and (c) the factors that influenced their use of technology in the teaching and learning process. Sections 5.4 to 5.12 presented a detailed analysis of each teacher's technology integration process using the base model.

In terms of *RQ2*, the analysis revealed that most teachers integrated digital technologies for didactic pedagogical practices that maintained the traditional teacher-centred approach to teaching. Technology was mainly used as a presentation tool or to exchange materials that enhanced their pedagogical practices. The use of technology to conduct activities that foster active, authentic, and higher-order cognitive engagement was minimal. As for *RQ3*, several factors influenced teachers' technology integration endeavours. These included factors related to the teachers' personal attributes and factors related to their contextual environment and contributed to their decision-making regarding technology implementation in their lessons. Despite all three schools belonging to the government, teachers' experiences and challenges with technology adoption varied due to the differences in their contextual environment (e.g., facilities and resources, support received from the school and outside community). In the following chapter, the main findings from this study are discussed in light of reviewed literature on the integration of technology in teaching and learning.

Chapter 6: Discussion

6.1 INTRODUCTION

The current study explored Maldivian in-service lower secondary grade (grades 9 and 10) teachers' TPACK; integration of technology and its impact on teaching and learning; and the factors influencing their technology integration. The following research questions were explored to achieve this aim:

RQ1: What are Maldivian in-service teachers' perceptions of the constructs of TPACK (Technological Pedagogical and Content Knowledge)?

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

A two-phase, explanatory mixed-method study design was adopted to address the above research questions. In phase one of the study, a nationwide survey was conducted to explore in-service teachers' TPACK. To investigate how teachers integrated technology, its impact on teaching and learning, and the factors that influenced teachers' technology integration, nine teachers (volunteers from those who participated in phase one survey) representing three schools from three regions in the county were interviewed. The aim was to capture the variations (if any) present in teachers' use of technology, its impact on teaching and learning, and the factors affecting their technology integration efforts depending on the different regions.

This chapter is presented in five key sections. Section 6.2 discusses the teachers' TPACK perceptions. In Section 6.3, a discussion of how teachers integrated digital technologies in their classroom teaching and the perceived impact on students' cognitive engagement is provided. The factors that influenced teachers' integration of digital technologies in their classroom teaching are discussed in Section 6.4. This is followed by the model proposed for teachers' integration of digital technologies in teaching and learning in the Maldives in Section 6.5 and a summary of the chapter in Section 6.6.

KEY FINDINGS

Research question one ascertained teachers' perceptions of their TPACK at a national level (Key Finding #1). Research question two explored technology integration and its impact on teaching practices in a smaller sample (Key Finding #2). Research question three delved further into understanding the factors that influenced technology integration within this group of teachers (Key Finding #3) (*Figure 6.1*).

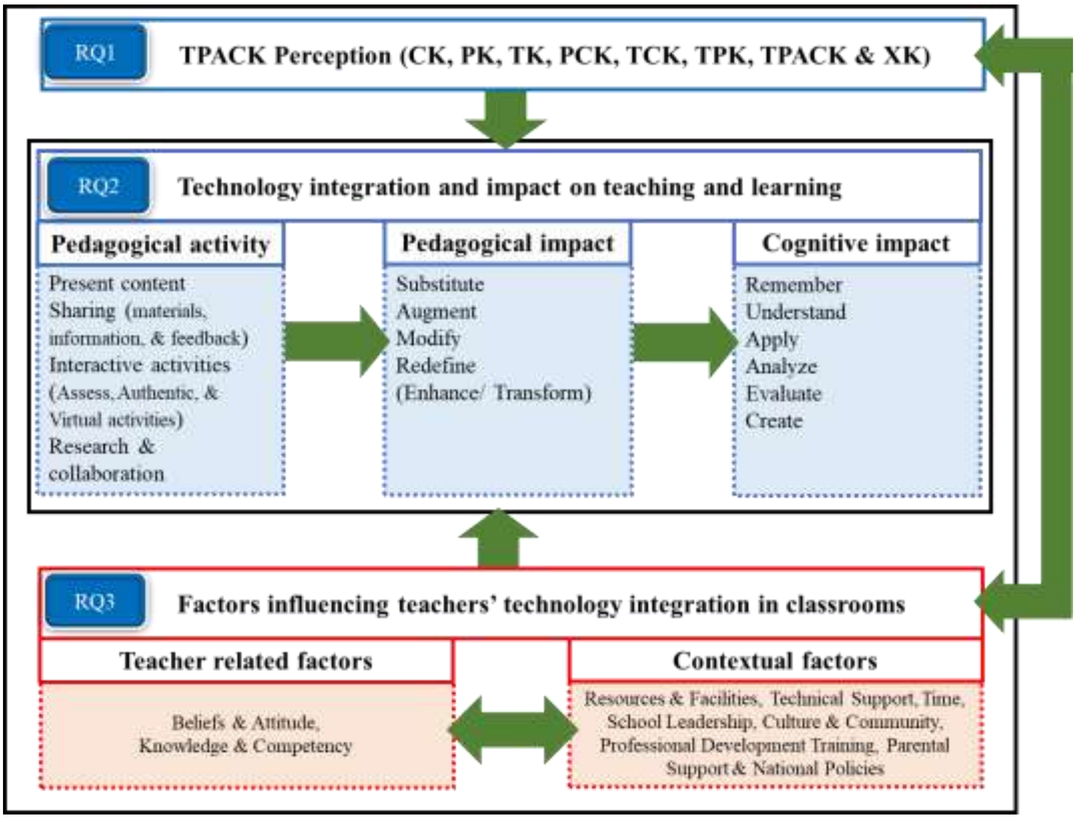


Figure 6.1: Conceptual model for teacher's integration of digital technologies in teaching and learning

Investigating the interplay of factors within and between the research questions led to the following key findings:

6.2 TEACHERS' TPACK PERCEPTIONS

The analysis of the TPACK survey data in chapter four showed that teachers in the current study rated their knowledge in the various constructs of the Technological Pedagogical Content Knowledge (TPACK) framework very highly (mean scores ranged from 3.93 to 4.65 on a 1-5 scale) (see Table 4.2). These findings concur with TPACK studies done by previous researchers who found high agreement on all the seven TPACK constructs (Barac et al., 2017; Koh et al., 2014; Owusu et al., 2015b). For example, Koh et al. (2014) measured the TPACK perception of practicing teachers in primary, secondary, and junior colleges in Singapore and their aim was to measure TPACK on the dimensions of meaningful learning. In contrast, Owusu et al.’s (2015b) study was specific to high school science teachers in New Zealand. Thus, the items for their TPACK survey were adapted from Archambault and Crippen (2009), Graham et al. (2009), Sahin (2011). The main aim of the current study was to get a general understanding of teachers’ perceptions across the constructs of the TPACK survey. This knowledge would provide an insight into teachers' current understanding of their knowledge and skills regarding technology integration. The participants were in-service teachers teaching in grades 9 and 10 in Maldivian public schools. Interestingly, the survey items in all three studies were guided based on Schmidt et al.'s (2009) original TPACK survey. It is also important to note that the sample sizes of Koh et al. (2014) study and the current study were reasonably similar (450 participants in Koh et al. (2014) study and 485 participants in the current study). However, Owusu et al.’s (2015b) study had a much smaller sample size (102 participants), which may have posed challenges in establishing its construct validity. Nevertheless, in all three studies, the factor analysis resulted in seven TPACK constructs.

Another main difference in the instruments was the Likert-scale measurement used to assess teacher's agreement or disagreement with the items. Koh et al. (2014) used a 7-point scale measurement that ranged from 1 (strongly disagree) to 7 (strongly agree), while Owusu et al.’s (2015b) survey and the current study used a five-point Likert scale (strongly disagree to strongly agree) to assess teachers’ perception of the items. Despite the differences in the contexts and the instruments, all three studies found that teachers perceived highly on their TPACK, with mean scores ranging 4.9 to 5.8 (scale) in Koh et al.’s (2014) study, and mean scores between 3.7 to 4.5 (scale) in Owusu et al.’s (2015b) study. These high scores imply that the teachers in both these contexts had high TPACK perceptions. Moreover, both studies also showed that the highest scores were on teachers' content (CK) and pedagogical knowledge (PK) domains, similar to the current study's findings.

According to Owusu et al. (2015b), possible reasons for the high CK perceptions include the prerequisite enrolment requirement (hold a specialised undergraduate qualification in science) that New Zealand teachers had to meet to enrol for a teaching qualification. These reasons are quite applicable in the Maldivian context too because secondary grade teachers in the Maldives must have a degree in their specialized subject area to qualify as a teacher to teach this grade level. The study done by Barac et al. (2017) to examine Australian university educators' TPACK perception based on a seven-factor instrument further supports these views.

Barac et al. (2017) rationalized the high mean scores of CK and PK on teacher educators' identifying strongly with their discipline first, which then helps them shape their values and behaviours. This would suggest that teachers are already knowledgeable in the content area of their subject well before they joined the teaching profession.

In addition, the training Maldivian pre-service teachers undergo during their teacher education programme might have contributed to the high perception teachers had on the constructs of CK and PK. The studies conducted by Owusu et al. (2015b) and Archambault and Crippen (2009) on the TPACK of online educators in the USA offer evidence for this assumption. They believed that the initial teacher education programme might have prepared teachers well in content knowledge and pedagogical skills. According to the Education Sector Plan, the Maldivian teacher education programs seem to have a similar focus of developing pre-service teachers' content knowledge and pedagogical skills (Ministry of Education & Ministry of Higher Education, 2019), which perhaps explains the high scores on the CK and PK of in-service teachers. Adding to this confidence would be the experience teachers gain once they join the teaching professions, which will help them strengthen their content and pedagogical knowledge further (Archambault & Crippen, 2009; Barac et al., 2017).

A significant difference between Owusu et al.'s (2015b) study and the current study was on the technology domain, which was the lowest in Owusu et al.'s (2015b) study with a mean score of 3.7. In contrast, the mean scores for TK and its related domains in the current study were above 4.0, which shows high agreement on items in these domains (see Table 4.2). Owusu et al. (2015b) believed that the lower score could be linked to teachers' years of teaching experience. Most teachers had been teaching for more than 10 Years which meant that they would have done their teacher training when technology was not so advanced and, therefore, might not have been an explicit part of teacher training programmes. Nevertheless, they concluded that the high scores on the remaining technology domains meant that teachers believed they could effectively integrate technology in their teaching. The higher TK scores in the current study may be attributed to the recent technology training teachers did in preparation for the rollout of the 'Digital School' project in 2018 (Ministry of Education, 2021). The project required all teachers teaching primary to secondary grades to complete the basic and intermediate training on the Google education series. This was evident in the data provided by the interview participants. They all had completed this training in the latter half of 2018 (see Sections 5.4 to 5.12). Perhaps, undergoing the training so recently (close to the time data for this study was gathered, which was mid 2019) might have boosted the teachers' perception of their knowledge in these technology domains.

The findings from this study also contradict Owusu et al. (2015b) and many other researchers regarding teachers' PCK (Archambault & Crippen, 2009; Barac et al., 2017; Graham et al., 2009; Koh et al., 2014). As stated in chapter three (see Section 3.10.2), the number of items in this scale was only two (one item from the original three-items in this construct had to be dropped during factor analysis as it did not yield the minimum factor loading criteria of 0.4) which might have affected the overall mean score for the scale. Thus, the PCK scores are interpreted with caution. Nevertheless, a possible explanation for the lowest agreement for the items on the pedagogical content knowledge (PCK) domain in this study may be related to the teachers' teaching qualifications. The demographic data shows that 11% of the participants had not undergone formal teacher training (see Appendix D). In effect, the draft report on the ICT Master plan indicates the percent of untrained teachers at 20% (Ministry of Education, 2021). As Shulman (1987) and others (Angeli & Valanides, 2009; Mishra & Koehler, 2008) contended, without proper training, teachers would lack the skills needed to apply appropriate pedagogical strategies to facilitate student learning. For such transformation to occur, Shulman (1987) states that teachers need to interpret their content knowledge, explore alternative pedagogical strategies and tailor the instructional materials to suit students' needs based on their prior knowledge.

Besides, according to the ESA 2019 report, the curriculum review conducted in 2016 revealed that a “large proportion of teachers in the system needed to “upgrade their content and pedagogical knowledge in order to deliver a competency-based curriculum” (Ministry of Education, 2019, p. 213). Significant issues identified include the lack of detailed lesson planning by teachers, especially in schools where the untrained temporary/contract teachers were higher, lack of support and supervision by the Leading Teachers (e.g., checking lesson plans, organisation of coordination meetings) (Quality Assurance Department & UNICEF, 2019). These issues might explain the relatively lower PCK scores (see Table 4.2) as teachers may be lacking the skills to comprehend and contextualise the new and conceptually complex curriculum.

In summary, it can be concluded that, although the in-service teachers in grades 9 and 10 in Maldivian schools had a high perception of the TPACK constructs, there is an urgency to facilitate training and practical experience in order to upgrade teachers’ knowledge and competency to help them connect their content and pedagogical knowledge to deliver the competency-based curriculum successfully.

6.2.1. TPACK perception versus Nationality and Subject Discipline

Two very unique findings from the survey analysis that came to light were the significant differences in teachers' perception of TPACK constructs against their nationality and the subject discipline. The analysis revealed statistically significant differences in teachers' perception of their TPACK abilities based on their nationality and their teaching subject. A summary of the survey results versus evidence from current literature on these factors is shown in Table 6.1.

Table 6.1: *Teachers' TPACK constructs based on their nationality and subject discipline – Similarities and differences in the current study versus existing literature*

Factor	Current research	Existing literature	Context and Authors
Nationality	• Teachers of Indian nationality had a higher perception in all the TPACK constructs.	• Higher TK and CK in Australian teacher educators • Significant differences in teachers PCK, TK, TPK, TCK, TPC across the six countries with the lowest scores for Bhutan	Pre-service teachers studying in secondary teacher education programs in Australia and Israel – (Redmond & Peled, 2019) Teacher educators training teachers for primary and secondary schools across six countries in Asia and Europe (Bhutan, Denmark, Estonia, France, Malaysia, and Pakistan) – (Castéra et al., 2020)
Subject discipline	• Statistically higher TPACK perceptions for English language teachers, followed by Math teachers • Lowest confidence for all the TPACK constructs for the local language (Dhivehi) teachers followed by Islamic studies • English language, Dhivehi language, and Math teacher’s highest confidence in CK, and then PK • Islamic studies teachers reported the highest confidence in PK, and then CK	• No significant differences based on the teaching area (Math and Science, Humanities and Social Studies, and Health and Physical Education) among pre-service secondary education teachers • Science teachers had significantly higher TPACK than mathematics teachers • Significantly higher TPACK levels among natural science (science and mathematics) teachers compared to social science (literacy) teachers • Significantly higher mean scores in TPACK constructs by elementary teachers	Pre-service teachers studying in secondary teacher education programs in Australia and Israel – (Redmond & Peled, 2019) Taiwanese elementary mathematics and science teachers – (Jang & Tsai, 2012) Turkey pre-service teachers – (Tokmak et al., 2013) Elementary student teachers with subject specialist student teachers (Social Science Teaching, Science Teaching, Mathematics Teaching, and Turkish Teaching) at a university in Turkey – (Altun & Akyildiz, 2017)

6.2.1.1. **Teachers' nationality**

The comparison between the local and expatriate (Indian) teachers gave valuable insights regarding teachers' perception of their TPACK constructs, especially considering the limited international studies investigating teachers' TPACK based on their nationality. According to the demographic data, a large proportion of teachers (62.1%) in this study comprised expatriate teachers (see Appendix D). The multivariate analysis presented in chapter four evidenced that expatriate teachers from India scored significantly higher mean scores on the TPACK constructs except PCK. The scores on PCK were not significant and remained very similar for both groups (see Table 4.15). To understand these variances, it is crucial to examine the reasons for the presence of expatriate teachers in the Maldivian education system.

Firstly, the school statistics 2019 data shows that currently, there are 204 lower secondary schools in the country, and the majority (186) are located on the outer and more remote islands (Ministry of Education, 2019). However, the geographical spread and remoteness of the islands pose challenges for the MoE to hire qualified locals as most teachers are reluctant to take up teaching positions, especially if they have to work in the outer islands, away from their families (Ministry of Education, 2019). Thus, the government has been recruiting expatriate teachers (mainly from India) for the past four decades (Ministry of Education, 2019).

Secondly, as mentioned earlier, the demographic data revealed that 11% of the participants in this study had not undergone any formal teacher training (see Appendix D). The school statistics report published by the MoE also supported this finding. 11% of the local teachers did not have a formal qualification (teaching or other), while all the expatriate teachers had a graduate-level qualification. A caution is drawn on these findings since it was not possible to establish (from MoE statistics report nor from the data for current study) if the qualification expatriate teachers had was a teaching qualification (e.g., B.Ed., Graduate Certificate or Diploma in Teaching) or a specialized degree (e.g., BSc, BA, or BEng). Furthermore, the ESA 2019 report has shown that 20% of the local teachers lacked the minimum diploma level teaching qualification which has been a pressing issue for the government in providing an equitable education to all children across the country (Ministry of Education, 2019). Some of the significant issues highlighted in the report on the Education Sector Plan - 2019 to 2023 include the lack of skills among in-service teachers (a) to fully comprehend the new curriculum and facilitate student learning; (b) to conduct student-centred teaching, competency-based assessments; and (c) language (English) fluency issues (Ministry of Education & Ministry of Higher Education, 2019). While these issues were not specific to the local teachers alone, a significant concern evident from government reports and this study, as mentioned above, was the large proportion of unqualified teachers working in the system resulting in lower student performance. Thus, these teacher qualification issues perhaps, explain the reasons for the local teachers' lower perception in the TPACK survey constructs than the expatriates.

While the literature on teachers’ TPACK based on their nationality is scant, the study conducted by Castéra et al. (2020) comparing teacher educators' TPACK across six countries in Asia and Europe (Bhutan, Denmark, Estonia, France, Malaysia, and Pakistan) sheds some light for the reasons for teachers’ low PCK. They found that Bhutanese teachers had significantly lower perceptions on all the TPACK constructs, with the lowest scores on their PCK. The need for more pedagogical and content-related knowledge and teachers’ low professional esteem were identified as the main reasons for the low TPACK perception among Bhutanese teachers (Castéra et al., 2020). Similarly, issues with teacher professional esteem might have influenced the local teachers in the current study, as evidenced in the ESA 2019 and ESP 2019 reports. According to the ESP report, the Maldivian government faces challenges attracting and retaining capable and high-quality local teachers within the system “due to teaching not being perceived as an attractive profession” (Ministry of Education & Ministry of Higher Education, 2019, p. 47). The salary and incentives teachers receive influenced these views. However, the current study cannot substantiate this claim since data on these aspects were not gathered. Therefore, further research and analysis are necessary to fully comprehend the situation and the motivational aspects (teacher distribution and allocation, motivation and incentives, training, and professional development needs) for both groups.

Given the limited research exploring teachers' TPACK based on their nationality, this comparison adds to the current literature on TPACK studies. As stated earlier, the comparison of teachers' TPACK and nationality in existing studies mainly focused on teacher educators or pre-service teachers. No studies have been found on in-service teachers’ TPACK against their nationality. Secondly, in those studies, the teachers of different nationalities were compared while working in their own country. Thus, this study puts forth new perspectives on how teachers’ TPACK varies based on their nationality. However, further research focusing on this aspect is necessary to better understand these differences so that professional support can be maximized to promote teacher quality.

6.2.1.2. **Teachers’ subject discipline**

The reviewed literature demonstrated that few studies had compared how teachers' TPACK perceptions varied based on their subject *discipline* (Altun & Akyildiz, 2017). Of the few studies that have compared TPACK against their subject discipline, most focussed on pre-service teachers, and the results have not been conclusive. Thus, this factor was assessed in the current study. In the Maldivian secondary education system, students have four compulsory subjects and four optional subjects. The four compulsory subjects include English language, Mathematics, Dhivehi (local language), and Islamic studies. These four subjects were compared in this study as these are considered compulsory subjects that students need to pass to succeed to subsequent grade levels.

The between-subject analysis evidenced statistically higher mean scores in TPACK constructs for English language teachers, followed by Mathematics teachers (see Table 4.16). This finding is interesting because the Mathematics/Science teachers are usually considered more technologically literate (Tokmak et al., 2013). Conversely, the lowest confidence for all the knowledge scales was seen from the teachers teaching the local language Dhivehi followed by Islamic studies. For both the subject groups, teachers’ perceptions were the lowest on technology and its related domains. This finding is not surprising, considering the lack of technology application and materials available for the two local subjects Dhivehi language and Islam. Many applications are designed for children in developed countries, and therefore, suited to their curriculum.

The lack of content and context-specific technologies (e.g., subject-based digital text, stories, videos, online applications, websites in the local language) also means less opportunity for teachers in these two groups (Dhivehi language and Islamic studies) to adopt them in teaching their subjects. This could also mean that these teachers might not see the value of the technology tools available to them for their respective subject-specific contexts in their classrooms, resulting in lower TPACK perception (Ottenbreit-Leftwich, 2012). Thus, facilitating the development of content and context-based technologies specific to these two subjects, as well as creating avenues for teachers to discuss, model and experiment how to use the technologies in the context of their subject area could address this issue (Ottenbreit-Leftwich, 2012).

The findings on teachers' TPACK perceptions against their subject discipline are unique to the current study. As mentioned earlier, there exists limited research exploring teachers'

TPACK based on their subject discipline, and no studies have focused on the differences and issues pertinent to TPACK related to in-service teachers, nor to locally developed subjects (Dhivehi language and Islamic Studies) as identified in this study. This finding offers valuable insights, not only to the current study but also to the existing body of literature on TPACK concerning their subject discipline and within the context of in-service lower secondary grade teachers.

6.3 TEACHERS' INTEGRATION OF DIGITAL TECHNOLOGIES IN TEACHING AND LEARNING

How teachers utilize technology in the teaching and learning process determines its efficacy in student engagement and learning (Chandra & Briskey, 2012). This implies that to educate and instruct children using technology successfully, teachers must have the expertise and experience to do so. In this regard, this study determined the TPACK perception of Maldivian in-service lower secondary grade teachers, as discussed in the previous section (see Section 6.2). However, perceptions do not always translate into actions. This section discusses teachers' perceptions as evidenced by the scores in the TPACK survey and how they integrated technology within their practices. TPACK perception scores and frequency of using technologies in their classrooms by the nine interview participants are shown in Table 6.2.

Table 6.2: *Teachers' TPACK and the frequency of their use of technology*

Name	**Ameen**	**Malik**	**Lirgam**	**Anil**	**Suma**	**Fariyal**	**Shidhatha**	**Aanisa**	**Raihana**
TPACK Perception	4.3	4.2	3.9	4.1	4.3	3.9	3.6	4.4	3.7
Frequency of technology use	4	3	4	5	4	4	4	4	4

The above table shows that Ameen, Suma, and Aanisa had 'very high' TPACK perception and used the technology frequently (one or more times a week) in classroom teaching, while Malik, who also had 'very high' TPACK, rarely (a few times a month, at most) adopted technology in his lessons. Another interesting observation is Anil, who had a 'high' TPACK perception, adopted technology regularly (every day or almost every day). Likewise, Fariyal, Lirgam, Shidhatha, Raihana also had 'high' TPACK scores but used the technology less frequently (one or more times a week) in their classroom teaching.

Interestingly, these findings demonstrate that, teachers' perceptions of their TPACK did not have any bearing on the frequency of technology use. This is understandable, considering that the participants in the qualitative phase were from different contextual backgrounds (different school contexts, subject discipline), which might have played a role in their decision-making when adopting technologies. The results strongly suggest other factors (such as aim/objective of the lesson, availability of resources, timetabling, knowledge, and competency) influencing teachers' technology integration efforts, as discussed in upcoming sections (see Section 6.4).

The survey and interview data revealed that presentation software (e.g., MS PowerPoint) were the most familiar and most frequently used technology by the teachers. Puentedura (2012) postulates, the use of digital technologies such as PowerPoint to substitute or replace traditional teaching styles (e.g., ‘chalk and board’ versus PowerPoint), or augment (show video animation, move back and forth on the slides to repeat or clarify a point) enhanced teachers’ pedagogical practices. This type of teacher-centred use of technology limits student’s active involvement or interaction in their learning. Teachers also indicated familiarity with other digital technologies (e.g., assessment software, blogging apps, Tablets, virtual classrooms, collaborative software, discussion forums, web-based social media platforms, interactive boards, cloud-based apps, and adaptive learning platforms). However, only a few (three or fewer) used these in their teaching, and this use was sporadic. This is unsurprising, considering the limited technology resources and facilities accessible for teachers in their schools (see Section 3.12.1) and other contextual challenges they faced in integrating technology in their instructions (see Section 6.4).

6.3.1. Technology integration and the perceived impact on students' cognitive engagement

According to the teachers in the case studies, technology was an integral part of their instruction as it facilitated easier access to information and made concepts easier to teach and learn. They also claimed that it enhanced student engagement, improved students’ grasp of subject content, and continuously provided opportunities for students to study both inside and outside the classroom. All the nine teachers interviewed stated that they regularly used technology in some form, either to support their teaching or aid student learning. A compilation of the most common uses of digital technology reported by teachers is summarised in Table 6.3. The data presented in the table are drawn from teacher interviews and their perception of the TPACK survey. The first two columns captured the types of technology-based activities conducted and the devices used to conduct the activities. The third column shows who (teacher versus student) conducted the technology-based activity, to elucidate the extent of student participation in conducting the activities (teacher-centred versus student-centred). The fourth column represents how teachers’ use of technology impacted their pedagogy (Enhancement or Transformation) as per the SAMR model proposed by Puentedura (2012). The fifth column shows the researcher's interpretation of where the activity fell along the cognitive thinking skill dimensions on the Bloom's Digital Taxonomy (BDT) proposed by Churches (2008). This allowed ascertaining the level of student engagement in terms of the cognitive thinking (low-order versus high-order) required for the learning activities.

Table 6.3: *Summary of activities conducted using technologies, its impact on teaching and learning*

Technology-based activity	Technology device	Teacher / student centred	Impact on pedagogy- Enhancement/ Transformation (Based on SAMR)	Impact on cognitive thinking levels (based on BDT)	Ameen	Malik	Lirgam	Anil	Suma	Fariyal	Shidhatha	Aanisa	Raihana
PPT Video, Animations	TV, Internet, computer, Tablet, projector, PPT	Teacher	Enhancement (Augmentation)	Remember/ Understand	✓	✓	✓	✓	✓	✓	✓	✓	✓
Create presentations	TV, Internet, computer, Tablet, projector, PPT	Student	Transformation (Modify)	Evaluate/ Create	✓		✓	✓	✓	✓		✓	
Interactive MCQ	Online website, PowerPoint	Student	Enhancement (Augmentation)	Remember/ Understand	✓	✓		✓		✓	✓	✓	
Research collaboratively	Computer, Tablet, Internet	Student	Transformation (Redefine)	Evaluate/ Create	✓				✓			✓	
Virtual experiments, demonstrations	Computer, Tablet, Internet	Student	Transformation (Modify)	Analyse/ Evaluate		✓					✓		
Share materials, information, feedback	Computer, PowerPoint, Pen drive, Google Classroom	Teacher	Enhancement (Augmentation)	Remember/ Understand		✓	✓	✓	✓	✓			✓
		Student	Enhancement (Augmentation)	Remember/ Understand			✓						
Share materials, info & give instant feedback.	Google Classroom, Virtual LMS, social media (Viber)	Teacher	Enhancement (Augmentation)	Remember/ Understand							✓	✓	
Differentiated content delivery	Computer, Tablet, Internet, PowerPoint	Teacher	Enhancement (Augmentation)	Remember/ Understand								✓	
Differentiated group activity	Computer, Tablet, Internet, PowerPoint	Student	Transformation (Modify)	Apply/ Analyse				✓					

Peer teaching activities	Computer, Tablet, Internet, PowerPoint	Student	Transformation (Redefine)	Apply/ Create					✔			✔	
Project-based learning activities	Computer, Tablet, Internet, PowerPoint	Student	Transformation (Redefine)	Apply/ Create					✔			✔	
Differentiated assessments	Social media app. Viber	Student	Enhancement (Augmentation)	Understand/ Apply					✔				
	A*		**- Total enhancement activities**		**2**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**2**
	B*		**- Total Transformation activities**		2	**1**	**1**	**2**	**4**	**1**	**1**	**4**	**0**
	C*		**- Teachers' overall TPACK perception**		4.3	4.2	3.9	4.1	4.3	3.9	3.6	4.4	3.7
	D*		**- Reason for low overall TPACK perception**		TCK3.7	TPK3.3, PCK3.3	PCK1, TPK3.5	PCK2	All>4	TCK3.7, TK, TPACK3.8	PCK2.5, TCK2.7, TPK3.5, TK3.7	All>4	TCK3.3, TPACK3.3, TK3.5

Note:

- *Column1: type of activities conducted using the technology*
- *Column2: type of technology used to conduct the activity*
- *Column 3: who (teacher versus student) conducted the activity*
- *Column4: Impact of the activity on pedagogical practice (enhancement or transformation) based on the SAMR framework*
- *Column5: How the activity impacted student's learning engagement in terms of the six cognitive skill levels of the Bloom's Digital Taxonomy*
- *For each teacher, the total number of 'Enhancement' and 'Transformation' activities (rows marked A* and B*) are calculated by totalling the tick (✔) marks that fell under each category.*
- *The 'Teachers' overall TPACK perception score (row marked C*) is taken from the TPACK survey of each individual teacher*
- *The 'Reason for low overall TPACK perception' (row marked D*) shows which TPACK area was the weakest for each teacher*

As shown in Table 6.3, the most frequently cited use of digital technology took the form of augmentation (see Appendix Q) of teacher-centric pedagogy (Puentedura, 2012). This included multimodal/visual support for didactic pedagogies, sharing of digital materials, assessments, and tools for research. Teachers employed digital technologies to improve their pedagogical practices, including sharing materials online instead of printed sheets, online MCQ quizzes instead of paper-based quizzes, YouTube clips, or classroom videos. As Hamilton et al. (2016) postulated, the use of technology (e.g., use the Internet to share materials, MCQ quizzes, or show YouTube videos) results in some functional improvement in the pedagogical activity carried out. The technology-driven instructional activities help enhance the learning process, with minimal development of learning skills (Keane et al., 2016). It does not alter or change the learning outcome (Patton, 2015). Therefore, the use of digital technology for these activities engaged students at lower-level thinking in Bloom’s taxonomy (remembering and understanding), where they mostly were passive listeners and therefore required low cognitive engagement (Churches, 2008) (see Appendix R).

More innovative use of digital technologies by Ameen, Lirgam, Fariyal, and Anil resulted in higher student participation, feedback, and modification of prior practices as students could apply higher-order thinking skills to research and create artefacts. Likewise, Malik and Shidhatha's use of subject-specific technologies (GeoGebra and Virtual lab) helped modify the teaching and learning for students, whereby they applied their knowledge to analyse and evaluate mathematical/scientific problems. The use of technology in these examples evidences significant re-design of existing pedagogies and learning activities (Hamilton et al., 2016). It created opportunities for students to work on the task individually or collaboratively, both synchronously in class time and asynchronously out of class, resulting in learning transformation (Keane et al., 2016) (see Appendix Q). As proposed by Churches (2008), such activities create avenues for students to be engaged at higher cognitive levels (see Appendix R).

Suma, and Aanisa’s use of digital technologies to promote student collaboration and independent learning, helped redefine learning where students created and shared knowledge or carry out project work with their peers. Redefinition allows students to research, communicate and disseminate information collaboratively (e.g., project work, peer teach) by adopting technologies (Hamilton et al., 2016) (see Appendix Q). Thus, accomplishing activities at this level requires higher-level thinking skills from students, resulting in more cognitive engagement (Churches, 2008) (see Appendix R).

According to Puentedura (2012), digital technologies for substitution and augmentation lead to enhancement of practice, and modification and redefinition result in transformation. A two-dimensional matrix was created to visualize the pattern of teacher technology integration more clearly (see *Figure 6.2*). In the figure, teachers' TPACK perception (overall mean of the seven TPACK domains) is plotted on the x-axis, and the levels of technology integration as measured by SAMR are on the y-axis. The primary consideration to placing teachers on the matrix was the number of activities that led to either enhancement or transformation of pedagogies. If most of the activities reported by the participant resulted in enhancement, and if their TPACK perception was high, then the teacher's name was placed more towards the 'enhancement' (bottom right) side of the figure, regardless of whether there were activities that did result in 'transformation'. Likewise, if more activities reported by the participant resulted in transformation, and their TPACK competence was 'very high', then that teacher's name was plotted more towards the 'transformation' (top right) side of the figure. The letters within the brackets indicated the number of activities that resulted in either enhancement or transformation.

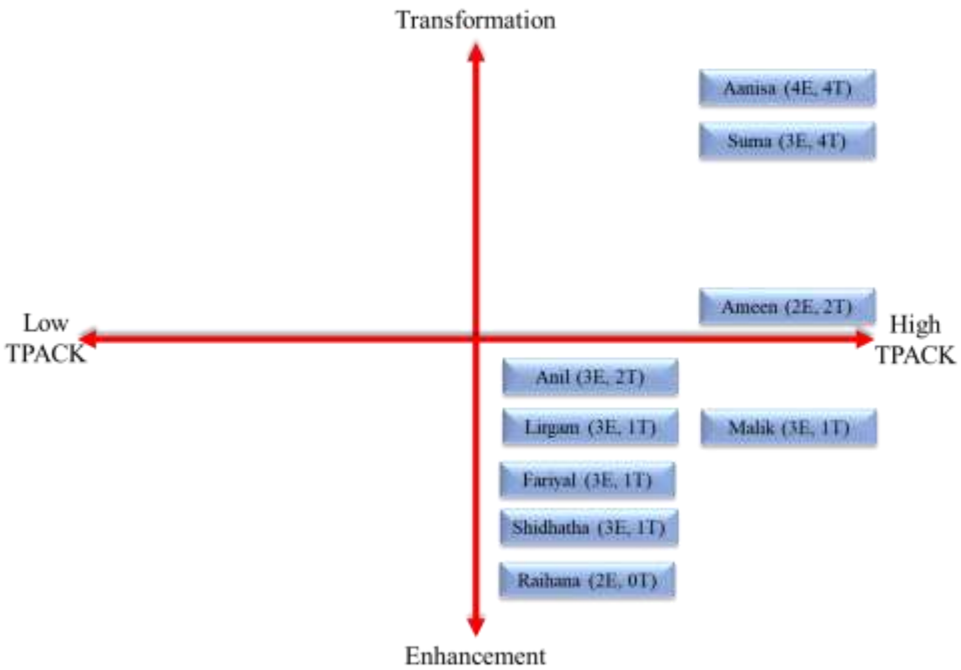


Figure 6.2: A two-dimensional matrix to visualise teachers' levels of technology integration (based on SAMR) and their TPACK. (E – Enhancement, T – Transformation)

From the above figure and the data analysis of the nine participants presented in chapter five (see Sections 5.4 to 5.12), it was apparent that only a few teachers who had 'very high' TPACK perceptions (Suma and Aanisa) managed to integrate technology at the higher levels of transformation, and this was infrequent. For most teachers (Malik, Ameen, Raihana, Shidhatha, Fariyal Lirgam, and Anil), technology was simply a tool to enhance their pedagogical practices. This meant that not all teachers with high TPACK perception always gave authentic, collaborative learning activities requiring higher-order thinking skills, thereby achieving higher cognitive engagement.

Observation of the individual TPACK constructs for these teachers shows that they had a lower perception of their PCK, TPK, or TCK domains (see Table 6.3). A lower score on these domains suggests lower confidence to leverage technology for different pedagogical activities to facilitate collaboration among students; help them construct different forms of knowledge representations; and plan and monitor their learning (Mishra & Koehler, 2006). This shows the need for teachers to make the appropriate connection between the various TPACK constructs to integrate technology effectively. As Mishra and Koehler (2006) proposed, a deeper understanding of the relationships of TPACK constructs could lead to more learning transformation when adopting digital technologies. The TPACK framework recognises the importance of the connections and interactions between content knowledge (what to teach), pedagogical knowledge (how to teach), technological knowledge (how to do so with the use of technology), and the transformation that takes place when combining these domains (Mishra & Koehler, 2006). To effectively integrate digital technology that leads to learning transformation, teachers must make this connection between technology, pedagogy, and content (Mishra & Koehler, 2006).

To summarize, the findings discussed in this section and the three theories (TPACK, SAMR, and BDT) applied to understand how teachers integrate digital technologies, and the perceived impact on student's cognitive engagement is unique to the current study. Thus far, none of the published literature on teachers' TPACK and technology integration has applied these three theories within one single study to investigate the phenomenon. Therefore, these findings contribute new knowledge to the literature on teachers' TPACK and technology integration. Also, despite the extant literature on TPACK and its importance for effective integration of technology, the teachers' TPACK perception in terms of their pedagogical practices and the resultant student engagement based on Bloom's Digital Taxonomy has not been reported in previous research. Against this theoretical assumption, this finding has demonstrated that not all teachers who perceived high TPACK engaged students at higher-order thinking effectively. These findings thus supported the theory that, while technological knowledge is an important domain, the success of technology integration relies on teachers' understanding of all three knowledge domains and their interconnections (Mishra & Koehler, 2006). It showed that, simply having 'very high' or 'high' TPACK perception alone may be insufficient if teachers have lower perceptions in other interconnected TPACK domains (e.g., PCK, TPK, TCK), and thus, teachers must be educated on the interconnected knowledge domains (PCK, TCK, TPK). These findings are crucial in understanding teachers' TPACK, especially when planning to implement technology projects or designing professional development programs on technology integration to promote meaningful student learning. Nonetheless, it is forewarned that these findings are to be read with caution as several other factors influenced teachers' technology adoption, which is discussed next.

6.4 FACTORS INFLUENCING TEACHERS' INTEGRATION OF DIGITAL TECHNOLOGIES IN TEACHING AND LEARNING

The discussion presented in this study has shown that in-service teachers in grades 9 and 10 in Maldivian public schools typically had high TPACK perceptions, and to some extent, this perception did influence how they integrated technologies in their instruction. Similarly, the variations observed from each teacher on how they incorporated the technology resources, despite having similar TPACK perceptions, has shown that there were other factors that affected their technology integration efforts. Two key themes emerged from the interviews regarding these factors and how they influenced teachers' TPACK and implementation of technologies in classrooms. These included factors related to the teachers and their context (see *Figure 6.3* below). The rest of this chapter discusses these factors in light of existing literature.

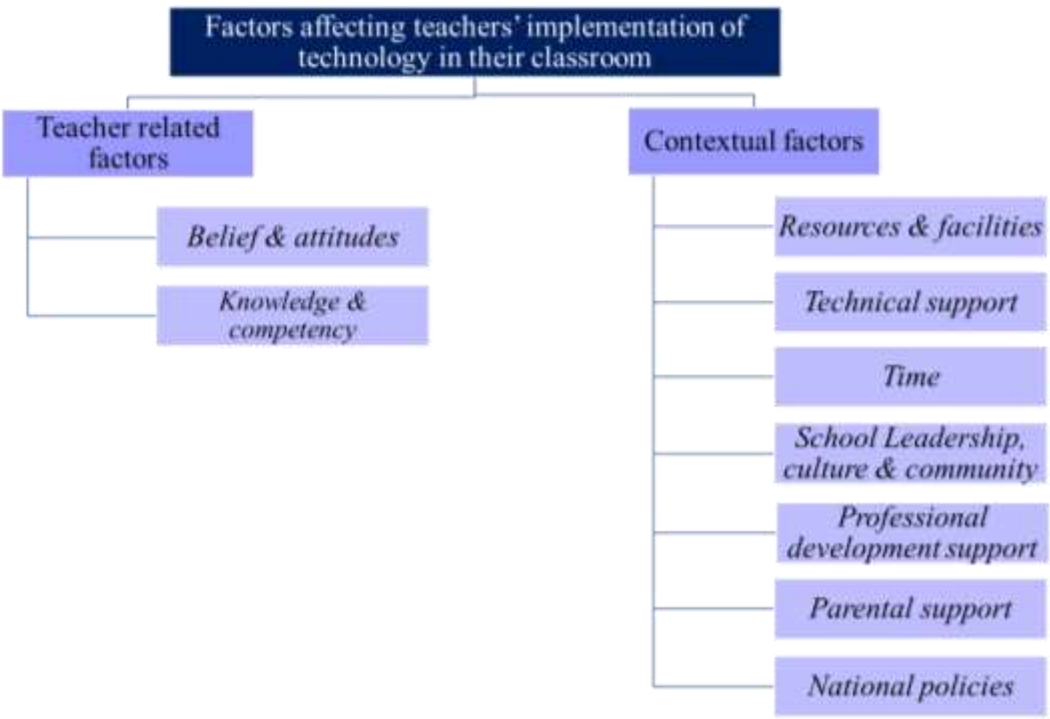


Figure 6.3: Factors that influenced teachers' integration of technologies in teaching and learning in the Maldives

6.4.1. Teachers' beliefs and attitudes

Congruent to existing research, this study also found that teachers' beliefs and attitudes affected their intentions and how they utilised technology in their lessons (Adam, 2015; Ali, 2015; Barak, 2014; Hew & Brush, 2007; Kinaanath, 2013; Neira et al., 2018; Spiteri & Chang Rundgren, 2020). That is, teachers' acceptance of technology (TAM), their behaviour, and intention to use technology were affected due to their attitudes toward technology, especially on the perceived usefulness and ease of using the technology in their teaching (Kinaanath, 2013; Schepers & Wetzels, 2007). Beliefs and attitudes about technology integration relate to teachers' overall sentiments towards using technology in teaching and learning processes (Lawrence & Tar, 2018). This may include positive or negative perceptions (see *Figure 6.4*) teachers associate with technology and depend on several teacher-related factors such as technology knowledge, confidence, competence, perceived benefits, and drawbacks (George & Sanders, 2017).

For most participants, having high TPACK perceptions was not analogous to the more transformative use of technology in their teaching. Hence, as Barak (2014) puts it, a "techno-centric and tokenistic" (p. 12), use of digital technologies was observed from most participants. According to Barak (2014), this might be associated with teachers' beliefs and attitudes towards technology integration (Barak, 2014).

Positive beliefs

- Motivate students
- Create challenging environment
- Create authentic learning experiences
- Engage students actively to construct knowledge and skills
- Student groups discuss lessons, do peer teaching (beneficial, for slow learners, to grasp the concepts quickly)
- Promote self-directed learning
- Foster meaningful learning
- Nurture higher-order thinking skills
- Benefits for student learning under challenging circumstances

Negative beliefs

- Technology not suitable to help students achieve high grades in the subject
- Nature of the subject (content-heavy and exam-oriented)
- Reluctance to change the traditional teaching methods
- Early established pedagogical beliefs (e.g., cover large amounts of content, saves time explanation easier, rote learning, drill and practice)
- Misguide students into engaging in inappropriate behaviour
- Weakens teacher authority and brings about distractions
- Low self-efficacy and confidence towards technology

Figure 6.4: Participants' beliefs about adopting digital technologies in teaching and learning

For example, though Raihana obtained a ‘high’ score in the TPACK perception survey, she declared that she was “very unfriendly with technology and was not enthusiastic” about learning technology for teaching purposes, suggesting a low self-efficacy towards technology. Thus, providing such teachers with excellent ICT facilities may not influence them to use it in their teaching, especially if they have preconceived negative beliefs or lack the confidence to use technology in their classrooms (Barak, 2014; Lawrence & Tar, 2018; Spiteri & Chang Rundgren, 2020)

Moreover, research shows that unless teachers understand and believe in the benefits that technology can deliver to their teaching and students’ learning, they may circumvent it (George & Sanders, 2017; Hew & Brush, 2007). The analysis of Raihana's interviews showed that her philosophical values regarding technology in her lessons were congruent to these views. She did not believe that using technology was the best strategy to help students achieve high grades in mathematics. Thus, her use of technology for student-centred activities was less frequent, as observed from her interviews (see Section 5.12).

As Barak (2014) and Spiteri and Chang Rundgren (2020) asserted, the discontent beliefs can be further exacerbated if teachers feel that technology (e.g., iPad, Tablets) misguided the students into engaging in inappropriate behaviour, affecting the plan of their lesson activities. Thus, despite having high TPACK perception, the belief that certain types of technology (e.g., Tablets) makes it challenging to keep the class under control prevented some teachers (Ameen, Malik, Raihana) from going for technology-based, student-centred strategies (see Sections 5.4, 5.5 and 5.12). These evasions may be exacerbated if teachers lack confidence in using technologies and thus will unlikely be drawn away from their traditional teaching approaches (Jimoyiannis, 2010). The technology gets the blame, as such teachers view it as an inefficient tool that weakens their authority and brings about distractions in their classroom, and thus, push it to the side (Barak, 2014).

Moreover, in one of the few studies done to understand the impact of Maldivian teacher educators’ culture and background on their pedagogical and technological practices, Adam (2015) found that the beliefs teachers hold regarding technology use are often connected to the nature of their teaching subject. This could be true for Malik and Raihana, who felt that their subject's content-heavy and external exam-oriented nature barely gave sufficient time to cover the syllabus (see Sections 5.5 and 5.12). Thus, this might have conflicted with their purpose of using technology, as they were more concerned that technology was taking time away from teaching the subject content. In fact, Adam (2015) argues that the exam-oriented, content-heavy curriculum in the Maldives has often driven teachers to adopt more traditional pedagogical approaches, which impacted how they implement technology in teaching. Similar findings have been reported by Kinaanath (2013) on his study on using information and communication technology in teaching and learning within higher education sector in the Maldives.

Researchers further argue that the traditional pedagogical practices teachers adopt are linked to their early established pedagogical beliefs (Adam, 2015; Ali, 2015; Barak, 2014; Kinaanath, 2013; Spiteri & Chang Rundgren, 2020). This phenomenon was observed from the interview analysis of all the participants. They believed that technology was used to cover large amounts of content in a limited time, as it saved time and enabled their students to understand their explanations with greater ease. Thus, their focus was mainly on using the available devices in teacher-centric ways to enhance their teaching by mostly showing PowerPoint presentations or videos (Adam, 2015; Barak, 2014; Kinaanath, 2013). There was little or no consideration or justification for their student's use of technology for learning or promoting higher-order thinking skills (Adam, 2015; Barak, 2014).

Perhaps the rote learning styles teachers experienced during their schooling years might be coaxing them to apply these strategies in their teaching. Typical examples include teachers' use of PowerPoint presentations to explain lessons, followed by a set of questions given to assess students' understanding. This practice was common for all the participants. These teacher-centred approaches indicate a belief system that coincides with the more drill and practice type of pedagogy identified by previous researchers (Adam, 2015; Barak, 2014; Kinaanath, 2013). Contrarily, Barak (2014) and others (e.g., (Barak & Dori, 2009; George & Sanders, 2017)) who proclaimed that teachers with more constructivist-oriented beliefs often adopted digital technologies to conduct more student-centred activities in their lessons (Barak, 2014). This was discerned from Suma and Aanisa’s interview analysis. The focus of using technology in their classes was not merely as a tool for presentation but to emphasise student interaction with technology for more active and constructive learning. These teachers understood that using technology to conduct inquiry-based teaching approaches motivated students, and the challenging environment that resulted from the adoption of these strategies led to improved results (Clarke, 2016). They professed that rather than using technology in traditional ways, its affordances should be used to create authentic learning experiences that engage students actively to construct knowledge and skills (Adam, 2015; Barak, 2014). Thus, peer teaching was encouraged in their classes, where student groups used technology to present and discuss lessons (see Section 5.8 and 5.11). Teachers found this strategy beneficial, especially for slow learners to grasp the concepts quickly and promote self-directed learning (Kucuk, 2018). These teachers' innovative integration of technologies helped foster meaningful learning and nurtured higher-order thinking skills (Barak & Dori, 2009; George & Sanders, 2017).

This study also supported previous research on teachers' perseverance to continue using technology under challenging circumstances based on how the teachers view technology and the value they assign to it (Al Harbi, 2014; Ertmer, 1999). For example, the use of the social media app 'Viber' by Suma shows how the positive beliefs and values she held towards using technology for the benefit of student learning aided her in overcoming the many constraints she was facing using technology ubiquitously. Thus, even though the technology resources were limited, having a more robust vision and positive belief and attitude towards technology use were observed to predicate greater levels of technology implementation. This further emphasises the literature that the effectiveness of technology implementation relies on the teacher and not on the technology itself (Chandra & Briskey, 2012; Ertmer, 1999). Thus, teachers will find means to adopt technology, provided they perceive it beneficial for them and their students, regardless of the many challenges.

6.4.2. Knowledge and Competency

As evidenced in the preceding sections, despite having high scores in the TPACK survey (Section 6.3) and positive beliefs (Section 6.4.1), the majority of the in-service teachers in this study typically integrated technology to transmit knowledge. The use of technology for students-centred practices that foster higher-order thinking skills was less frequent. This may be the case if teachers lack the knowledge and skills required to adopt technology for more meaningful, constructivist-oriented pedagogical practices. In fact, research has shown that while positive beliefs and attitudes are essential, teachers may not be able to integrate technology in meaningful ways if they lack the necessary knowledge and competence (Bingimlas, 2009; Hew & Brush, 2007; Mukherjee, 2013; Pelgrum, 2001) Table 6.4 shows the broad categories of key knowledge areas teachers need to be competent to engender innovative technological pedagogies identified within literature and found from the current study.

Table 6.4: *Key knowledge areas for teacher competence to leverage digital technology for meaningful learning practices*

TPACK and self-knowledge	• Competence in TPACK constructs (TK, CK, PK, PCK, TCK, TPK, TPACK, XK) • Beliefs and values about teaching and learning, especially using DT	(Mishra & Koehler, 2006), (Angeli & Valanides, 2009) Found in both literature and current study
Students	• Existing cognitive knowledge base • Differences in cognitive style and visual literacy skills Students' content-related difficulties. • Characteristics and preconceptions that they bring to a learning situation	(Angeli & Valanides, 2009) Found in both literature and current study
Curriculum and lesson planning	• Competency-based teaching, assessment, and lesson planning when adopting technologies	(Chen & Wei, 2015) Found in both, but focus on PCK. The current study relates this to TPACK
Instructional design principles	• Knowledge about different strategies that can be adopted when integrating technology in lessons	Not found in the literature

The rows shaded in blue highlight the knowledge and skills teachers required as identified within the literature (Angeli & Valanides, 2009; Koh et al., 2014; Mishra & Koehler, 2006). The last three rows, coloured in orange, were knowledge areas identified by the present study's participants, which they believed were essential to integrate technology effectively and are discussed below.

Teachers' TPACK competence and self-knowledge

According to George and Sanders (2017), facilitating teachers to develop more technology knowledge and competence could change their beliefs and attitudes and vice versa. This change was observed in the case of Ameen, who was very reluctant to adopt technology in his teaching during the early years of his teaching (see Section 5.4). The knowledge and skills he acquired from professional development workshops at a nearby island positively influenced his ability to incorporate technology more frequently in his lessons (see Section 6.4.7). However, as with the other participants, his integration of digital technologies was mainly focused on enhancing his lesson delivery strategies. The high scores across the TPACK constructs from Ameen’s survey were not reflected in his practices. This was true for the majority of the interview participants (see Sections 5.4 to 5.12). Dunning et al. (2003) used the term "leniency bias" to explain this phenomenon. According to Dunning et al. (2003), participants may rate their perceptions highly in self-rating surveys if they are unaware of their incompetence in many intellectual domains, resulting in overconfidence, primarily if they regularly use technology in their daily lives (Dunning et al., 2003; Maderick et al., 2016; Schmid et al., 2021; Staus et al., 2014). The findings discussed in Section 6.3 on how teachers used technology also supports this claim, which showed that although teachers frequently used technology, this use mainly was to enhance their pedagogy.

Moreover, as George and Sanders (2017) contended, most teachers' traditional pedagogical beliefs and practices indicate critical knowledge gaps in leveraging technology meaningfully to teach their subject. In fact, as observed from the TPACK survey results of the nine participants, the scores on PCK, TCK, and TPK constructs were the lowest for the majority of the teachers (see the row labelled D* on Table 6.3). The lower score on these knowledge constructs could be attributed to two critical factors: the proportion of unqualified teachers and issues with professional development training related to the recent curriculum reform.

First, as discussed earlier, the education system had a high percentage of untrained teachers (see Section 6.2). As Shulman (1987) argued, such teachers would lack the necessary pedagogical skills to foster higher-order thinking skills in students by exploring alternative strategies, tailor the instructional material to suit students' needs based on their prior knowledge. Second, the focus of most professional development programmes has essentially been on developing teachers' TK (see Section 6.4.7). This would mean that teachers might not have received the necessary support to connect their PCK, with TPK and TCK, in designing technology-based lessons relevant to their specific subject. Several studies have argued about the ineffectiveness of the aforementioned approach of training teachers to develop their technology skills for school-based technology integration ventures (Adam, 2015; George & Sanders, 2017; Koh & Chai, 2016).

In fact, Koh and Chai (2016) have raised concerns regarding the low emphasis on developing teachers' TPK and TCK when designing technology-based lessons. They explored the influence of lesson design frames on primary teachers' TPACK considerations in Singapore and found that teachers' design frames such as idea development, perception, enactment, institutional considerations affected teachers' TPACK. Thus, they theorized these lesson design factors are essential for successfully integrating student-centred ICT lessons (Koh & Chai, 2016). Furthermore, teachers' skills in managing and manoeuvring the design processes and design resources, collegial engagement, and reflection-in-action were also identified as critical aspects for teachers to successfully utilise digital technologies (Koh & Chai, 2016).

The current study found that the training undertaken by teachers was inadequate to help develop the type of skills proposed by Koh and Chai (2016), as evidenced by the teachers' remarks regarding most of the formal training programs (see Sections 5.4 to 5.12). They believed they lacked adequate knowledge and skills to adopt technology to teach their subject in more engaging ways. This shows the importance of developing teachers' pedagogical and technological competencies pertinent to their subject (PCK, TCK, and TPK) to help them fully utilise digital technologies for student-centred, meaningful learning that promotes higher-order cognitive abilities.

Knowledge of students

In general, the teachers interviewed in this study were aware of their student's cognitive abilities, differences in learning styles, and content-related difficulties. But very few teachers adopted pedagogical strategies that appropriately catered to the different student abilities in ways that transformed the content while considering students' prior understanding and content-related difficulties. According to Angeli and Valanides (2009), teachers should be aware of the student's abilities and the type of topics that are usually too abstract or difficult for students to understand and are difficult for teachers to explain without some digital technology. They also argued that such awareness would help teachers tailor the lesson to students' specific characteristics, such as prior knowledge and preconceptions (Angeli & Valanides, 2009; Valanides & Angeli, 2008).

The findings from the current study have shown that teachers were aware of their students' skills and abilities. One example was Malik's use of the GeoGebra app to explain the 'circle theorem' concept, which shows his awareness of his students' abilities. His belief that the topic was complex for students to grasp and the affordance the app gave him to visually demonstrate how the angles of the circle vary were all essential considerations he made in adopting that particular technology to teach the topic. In fact, research has shown the affordances digital technologies create through visualisations of abstract concepts (e.g., mathematics, science) enhances students' engagement with and learning (Geelan et al., 2014; Mukherjee, 2013). Other examples include Shidhatha's use of virtual labs to conduct experiments, Suma's use of 'Viber' groups to cater to different ability levels when revising and Aanisa's use of peer groups to help students support each other's learning (see Sections 5.8, 5.10 and 5.11 for more details). These findings signify the importance of adopting effective pedagogical and technological strategies based on a sound understanding of student's cognitive abilities, the differences in learning styles, content-related difficulties to address student needs to achieve the desired learning outcomes (Angeli & Valanides, 2009).

Knowledge of curriculum and lesson planning

Literature discussing teachers' curriculum knowledge and how it gets enacted into lesson planning, especially in adopting digital technologies in their lesson and realising the specific curriculum goals, is sparse. In discussing the findings on this knowledge area, it is imperative to note that only four out of the nine teachers shared document artefacts (see Section 3.13). The participants who shared the document artefacts also shared the samples of just one of their lesson plans. Thus, it was challenging to precisely ascertain how they developed lessons when planning to adopt digital technologies in their lessons for all nine participants. Therefore, the discussion regarding teachers’ knowledge of lesson planning and assessment for curriculum enactment must be considered with caution.

The analysis of the lesson plans showed that these were very brief, and the focus of the lessons mainly was for teacher-centred activities; that is, to explain the lesson with the aid of a PowerPoint presentation and then give a worksheet as an activity to assess students' understanding of the lesson. These activities primarily targeted the lower levels of Bloom's cognitive domains. Besides, the assessment activities were very generic and lacked sufficient details about how the teacher expected to assess the learning outcomes against the key competencies. In general, the plans shared by participants did not offer clear evidence of how the lesson objectives set for each lesson were being achieved. Also, the lesson plans indicated that teachers adopted the available digital technologies to transmit knowledge for the traditional style of content delivery and drill and practice that promoted rote learning instead of helping students develop the eight key competencies mentioned in the new curriculum.

The issues illustrated above might be related to the curriculum reform in 2014. Teachers might have been struggling to comprehend and contextualise the new curriculum, which emphasises the child's holistic development through the incorporation of knowledge, skills, values, and attitudes based on eight key competencies:

1. Practising Islam
2. Understanding and Managing Self
3. Thinking Critically and Creatively

4. Relating to People
5. Making Meaning
6. Living a Healthy Life
7. Using Sustainable Practices
8. Using Technology and the Media

(Maldives National Curriculum Framework, (NIE, 2014))

Indeed, the review done by the Quality Assurance Department has found that a large number of teachers within the system had not been able to help their students achieve the key competencies (Quality Assurance Department & UNICEF, 2019). The review also found that teachers lacked skills in lesson planning, especially in schools where the numbers of untrained temporary/contract teachers were higher (Quality Assurance Department & UNICEF, 2019). According to the report, this was partly related to the lack of adequate supervision by the Leading Teachers assigned to check the lesson plans, organize coordination meetings and provide support and guidance to help teachers prepare better (Quality Assurance Department & UNICEF, 2019).

The specific issues of teachers' lack of knowledge and skills in implementing curriculum and planning lessons for competency-based activities and assessments are considered unique to the current study context. It symbolizes an urgent training need to provide necessary support and guidance to teachers to achieve the holistic child development goals set in the new curriculum. Teachers need to be adequately trained to implement the new curriculum and develop proper lesson plans to accommodate key competencies. Moreover, considering that 'Using Technology and Media' is one of the key competencies of the new curriculum (NIE, 2014), the basis of this training should focus on the use of digital technologies when providing that training.

Instructional design principles

This study has found that teachers lacked knowledge of instructional design (ID) models necessary for successful technology integration, and they were keen to learn more about these models (see Sections 5.4 to 5.12). Knowledge and awareness about some pedagogical design models can be beneficial, especially during the lesson design stage. This understanding can enable teachers to decide how a particular technology can be adopted to conduct activities to achieve specific learning outcomes for their subjects.

Although the literature has discussed several instructional design models, it does not explicitly indicate this as a knowledge teachers require for effective and meaningful technology integration. However, the participants in this study believed they required knowledge about instructional design to integrate technology in their lessons effectively. Thus, teachers' knowledge of different instructional design models is unique to the knowledge needed for the constructivist-oriented pedagogical use of technologies.

6.4.3. Resources and facilities

Issues with access to technology resources and facilities were a recurrent theme in this study. All the participants reported having faced resource-related challenges using technologies, whether teaching or conducting learning activities with their students. Teachers raised concerns about the lack of technology resources and their condition (outdated or broken), which prevented them from conducting technology-based teaching activities (see Sections 5.4 to 5.12). As a result, they were "forced to teach in the traditional [teaching] style", even "though [they] had done much preparation [e.g., created PowerPoint presentations" (Ameen). The remaining participants mentioned more examples of similar difficulties. For instance, Lirgam declared that conducting listening activities in his subject was "a huge problem [because the] speakers [were broken]". According to him, the school's "condition [regarding technology resources was] very poor". Although he had been "requesting them [for a speaker system] for years," the school had not been able to purchase one. Others voiced similar concerns and added that "the [lack of] … software" (Anil) and unavailability of information or "video [on] that "technology [application]" (Aanisa) were issues that affected their technology integration decisions.

As seen from the above discussion and chapter five (see Sections 5.4 to 5.12), the lack of adequate facilities and resources was most prominent at School A (Ameen, Lirgam). This may perhaps be related to its geographical location (located remotely) far from the capital city. According to the ESA 2019 report, one of the main constraints of achieving the goal of equitable quality education in the Maldives is associated with the "high unit costs of infrastructure and other public services," which is largely due to the geographic dispersion and remoteness of the islands (Ministry of Education, 2019, p. 167). Thus, considering its geographic location, these issues might have impacted the provision of facilities and resources for teachers at School A.

Limited technology resources also meant that teachers had to share these between many other classes. However, accessing commonly shared rooms (e.g., Audio-visual, computer lab) was problematic for teachers who wanted to use technology, especially in resource-restricted schools (e.g., School A). They (particularly Ameen, Lirgam) struggled to book shared spaces (e.g., AV room, computer lab), as they were usually occupied (e.g., computing classes, language classes). Other subjects took precedence for these shared spaces. Consequently, the teachers rarely had the opportunity to use technology in their teaching.

The analysis of qualitative data has also shown that the lack of Internet and Wi-Fi access within the school premises hindered teachers integrating digital technologies in their instructions. Indisputably, all the nine interviewees mentioned that they did not have Internet or Wi-Fi access in their classrooms and thus claimed that it was the most significant deterrent for them to conduct technology-based teaching and learning activities in their classrooms. Moreover, in the locations where Wi-Fi was accessible, teachers could not use it due to the weak signal strength resulting in too much time to load (e.g., website, videos) what they wanted to show students. Thus, to avoid embarrassment and save face in front of students, teachers hesitated to use the Internet, as it often gets disconnected, and they were unsure when it would happen. The few teachers who managed to show videos downloaded them before their lessons and showed them offline. Due to these difficulties, most teachers felt it was too tedious and cumbersome to use the Internet. Thus, they opted for the traditional approach, which minimally engaged students in learning.

Issues with the Internet and Wi-Fi in Maldivian schools are a significant challenge for government schools as they run on a constricted budget. According to the ESA 2019 report, more than 70% of the 213 schools have an Internet connection. However, the connection speed for the majority (70%) of the schools is between 4 to 8 Mbps. In most schools, this is usually shared by students, teachers, and school administration (Ministry of Education, 2019). These bandwidths are barely enough even to connect two classes concurrently. However, considering the high internet prices in the Maldives and the budget constraints, the government cannot afford higher bandwidth for schools (Ministry of Education, 2019).

These findings concur with what has been reported in the literature previously on the importance of resources and facilities, both in other SIDS contexts similar to the Maldives (Chandra et al., 2014) as well as in the developed world (Drossel et al., 2017; Francom, 2016; Hew & Brush, 2007; Kale & Goh, 2014; Lawrence & Tar, 2018; Makhlouf & Bensafi, 2021; Wright & Wilson, 2011; Yildirim, 2007). If teachers cannot access technology resources, then they will not be able to use them (Lawrence & Tar, 2018). Thus, providing teachers with the technology, equipment, and support and establishing mechanisms to share the limited resources to ensure maximum accessibility for all users is extremely important for successful technology integration (Al Harbi, 2014). More discussion of these resource-related issues follows under the school leadership, culture, and community support section (see Section 6.4.6) and the section on national level support (see Section 6.4.9) to further understand the implication of school leadership and government support in facilitating teachers with these resource-related issues.

6.4.4. Technical difficulties and IT support

Unanticipated technical problems discourage many teachers from using technology in their teaching, not because they are less enthusiastic or lack technology devices (Afshari et al., 2009; Francom, 2020). The lack of technical know-how can be detrimental to their motivation to use technologies (Buabeng-Andoh, 2012; Jones, 2004), especially if they lack the "knowledge to overcome [technical] problem[s]" (Suma). This worry intensifies if the school does not have an IT technician and the teacher does not know whom to approach to seek help with technical issues (Afshari et al., 2009). While there are many online resources that teachers can use to troubleshoot their technology woes, the teaching culture is still very much dependent of technicians to solve their issues. For instance, Raihana hesitated using technology in her class because, for her, technology meant "many other issues … like charge may not be there … something may switch off". Similarly, Lirgam remarked that the "Tablets [might] not [work] properly" or "students [could not] download the tracks", and the school's lack of an IT technician meant teachers had no support mechanisms to seek assistance to solve these technical issues. Subsequently, these issues disrupt the whole lesson as some students "[are unable] to do the work" (Lirgam), and lesson time is lost attempting to solve these technical issues. Hence, it disappoints teachers, especially when they "plan a lot, [and] … are unable to carry out that lesson" (Suma) as planned. These concerns from teachers show that teachers needed assurance that they will have the necessary technical assistance when things go wrong, without wasting time troubleshooting hardware and software problems (Lawrence & Tar, 2018).

Anil also felt the lack of support from the "right people … that is, the IT technician and other administrative [staff]" (Anil) was frustrating, especially when they request "to set something [e.g., update/install an app]" two to three weeks in advance to find that "it will not be done" (Anil) and therefore could not conduct the activity that was planned. Thus, the lack of support can become a barrier regardless of teachers' interest and familiarity with using technologies and discourage them from adopting and integrating technology in classrooms

(Korte & Hüsing, 2006; Lawrence & Tar, 2018). One of the reasons why technology initiatives fail even when the necessary software and hardware are provided is inadequate technical support and teachers' lack of awareness of where to seek assistance if something goes wrong while using computers (Korte & Hüsing, 2006; Lawrence & Tar, 2018).

Researchers also argue that when technical support is available in schools, it can positively influence teachers' abilities to apply technology in classrooms (Jones, 2004; Lawrence & Tar, 2018). For example, all three participants from School C (Aanisa, Shidhatha, Raihana) valued their IT technician's support as he was readily "available [to] assist [them with] whatever technical difficulties [they] faced" (Shidhatha). They believed that the availability of this support was a significant factor for the success of the VLMS implemented at this school. In contrast, Anil and other participants noted that the lack of "IT technicians' support" hindered teachers' technology adoption in teaching and learning. These findings indicate the need for schools to ensure the computer systems are maintained in optimal condition and teachers get the necessary technical support to motivate and encourage them to continue adopting digital technologies in their instructions (Afshari et al., 2009; Francom, 2020; Yilmaz, 2011).

6.4.5. Time

The teachers in this study discussed time (lack of) as a crucial factor in their decision to adopt technology in their lessons. The primary concerns with time identified in this study were related to the limited duration (35 minutes per lesson) of lesson time. Coined with this was the time lost in resolving technical issues, managing student behavioural issues, or moving between locations to access shared resources (e.g., computer lab, Audio-visual room).

For instance, Raihana's interview analysis (see Section 5.12) shows that the time lost in solving unanticipated “technical problems and so many other issues [student behaviour]” was a grave concern for her to evade using technology in her lessons. Raihana believed that using technology results in waste of her lesson time. Raihana's issues concerning time might be related to her low technology self-efficacy (see Section 6.4.1) and lack of prior preparation.

This aligns with Kopcha (2012), who found that teachers often form negative views regarding the time when introduced to innovative pedagogies, especially if it requires them to spend more time planning and dealing with classroom management issues (Belland, 2009; Wachira & Keengwe, 2010). Raihana’s belief that she was very unfriendly with technology, a lack of enthusiasm to learn, and the problems in managing student behaviour when using technology (Tablets) led her to opt for the default traditional pedagogical approaches as these issues were extra burdens on her. Thus, researchers (Groff & Mouza, 2008; Jones, 2004; Kirkland & Sutch, 2009; Renfrew Knight et al., 2009; Zhao & Frank, 2003) advise that schools need to facilitate additional time for teachers like Raihana to:

(a) familiarise with the new technology tool/application;

(b) plan the creation and implementation of the innovation;

(c) prepare the lesson;

(d) share innovations between teachers; and

(e) plan and reflect

However, even if the above requirements were met, Adam (2015) argued that teachers' pedagogical decisions to use technology largely depended on the time available to cover a very exam-driven syllabus. Similar views were reflected in some of the teachers' comments (Raihana, Malik, Anil) in the current study. For example, Raihana believed that with "only 35 minutes, [she would] not be able … to cover … the syllabus … if [she was] to use technology". Thus, she preferred to adopt more teacher-centred pedagogy (Adam, 2015; Al Harbi, 2014; Bingimlas, 2009; Hew & Brush, 2007). These findings demonstrate that teachers will continue to adopt more didactic pedagogical practices suitable to their specific contextual situations, if they feel time pressures; especially if they have a content-heavy syllabus to cover (Al Harbi, 2014; Bingimlas, 2009; Hew & Brush, 2007). The fact that digital technologies can actually facilitate learning is often discounted in favour of more conventional approaches.

This study also supported Al Alwani's (2005) study on the barriers to technology integration in Saudi Arabian science education, who found that the 45 minutes allocated to a single lesson was insufficient for teachers to conduct lessons integrating digital technologies effectively. Teachers in the current study (Anil, Shidhatha) described similar difficulties related to the duration of lesson time. For example, Anil felt that the "time allocated for each lesson [35 minutes])" was inadequate to conduct technology-based activities, especially when using shared rooms (e.g., laboratory, A/V room). He noted that it usually took five to ten minutes in-between sessions for students to reach the specified location and settle back for the lesson. He believed it was time-consuming, and valuable lesson time was lost, making it difficult for him to cover the activities he had planned for the class. These challenges thus minimized his capacity to adopt technology in his lessons.

Furthermore, the literature shows that the teachers having to take a heavy workload of 18 or more classes a week, coined with the high average number of students in classes were significant limiting factors to teachers' integration of technology in their instructions (Al Alwani, 2005; Al Sulaimani, 2010). According to the circular from MoE regarding period allocation, the average number of classes a secondary grade teacher is required to take ranges between 30 to 35 a week, and the classes in Maldivian schools; particularly in large schools, class sizes range from 25 to 32 (Ministry of Education, 2015). Thus, although not raised as concerns, teachers in the current study may have been adversely affected due to these workload-related issues identified by previous researchers (see (Al Alwani, 2005; Al Sulaimani, 2010)).

These findings demonstrate that issues related to time allocation (e.g., combat technical, classroom management, syllabus coverage, and time spent on moving to access shared resources) were an important factor for teachers' decision-making process when contemplating using digital technologies in their lessons. The time allocation issues resulting from moving from one location to another to access shared resources were not found in the existing literature and therefore are considered unique to the current study. These results further emphasise the need for school leaders and policymakers to find solutions that provide teachers adequate time and training to enhance their technological skills and better prepare for effective and efficient technology integration, and at the same time address the heavy teaching and curriculum load and assessing the ideal average number of students per classroom.

6.4.6. School leadership, culture, and community support

The findings from this study revealed (see Figure *6.5*) some critical leadership attributes of the school principal that either motivated or hindered teachers' adoption of technology in their instruction.

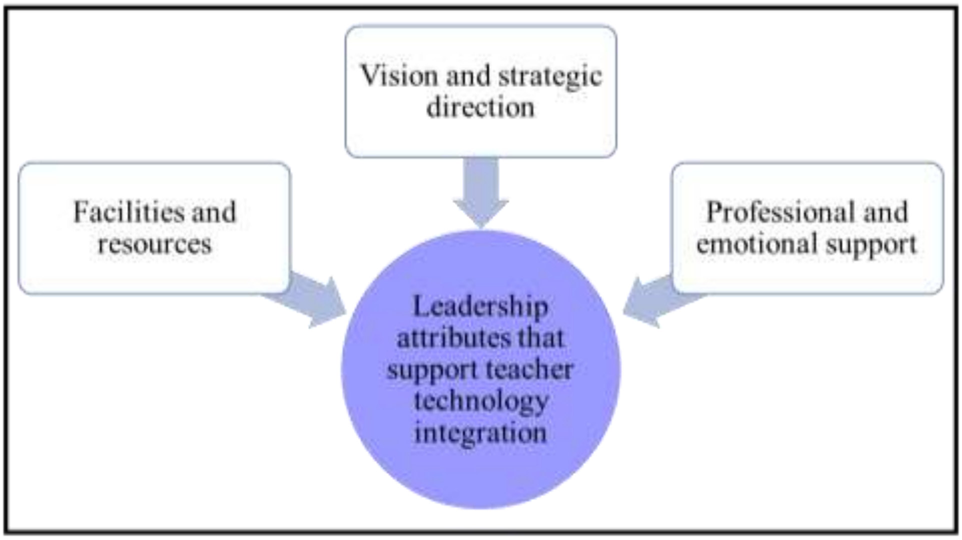


Figure 6.5: Key leadership support teachers found important to integrate technology

Facilities and Resources

The participants had mixed views concerning the support they received from their school principal regarding facilities and resources. Whereas participants acknowledged the support they received to prepare for their lessons (e.g., computer systems and internet facilities in the staffroom), they raised concerns regarding the lack of support with technology resources and facilities needed to conduct lessons (e.g., Smart TV, Internet, Wi-Fi inside the classrooms). These issues were more pronounced at School A, as evident from Ameen and Lirgam's remarks about the status of technology facilities and resources at their school (see Sections 5.4, 5.5 and 5.6). The school lacked the necessary classroom environment to conduct lessons using technologies. None of the Smart TVs located inside the classrooms or the speaker systems used for conducting listening activities were in working condition, and thus they were "forced to teach in the traditional sermon style" (Ameen). The teachers stressed that the school's inability to resolve problems with the devices (e.g., Smart TV) in the classrooms was gravely demotivating and blamed these issues on their school management. According to the participants (Ameen, Malik, Lirgam), their principal has not been proactive enough in maintaining/ upgrading the resources at the school. As Kirkland and Sutch (2009) and Lawrence and Tar (2018) alleged, a school management indifferent to teachers' problems regarding technology use can be very demotivating for the teachers, as was the situation for teachers at School A.

In contrast, a supportive and encouraging management can motivate teachers to integrate technology more successfully and help create a school culture that embraces such innovations more positively (Chandra, 2016; Kirkland & Sutch, 2009; Lawrence & Tar, 2018). This type of core leadership support was reported by the participants from Schools B and C. The teachers (Anil, Fariyal, and Suma from School B) highly valued the support they received from their principal (e.g., replace the old systems and then set up multimedia in different locations, improve the speed of internet). Likewise, teachers at School C expressed how their principal's leadership role encouraged teachers to work beyond the expected norm (e.g., teachers getting their own laptops for school use) and claimed that this helped resolve the issue of resource scarcity, as well as teacher dependency on others (the school) for resources. Further, teachers described how the availability of technical support, "always ready to help" (Shidhatha), eased teachers' insecurities, especially in using the VLMS. She believed that this (technical) support was crucial for the teacher's uptake of the VLMS in her school and attributed the success of the innovation to the school principal.

Vision and Strategic Direction

In discussing the school leadership support (or lack of) with technology infrastructure and resources, an important aspect that needs highlighting is how government schools in the Maldives acquire funding for resources. The facilities and resources at the schools usually are dependent on the budget they receive from the MoE, and this figure is calculated based on the student population (Ministry of Education, 2019). This means schools with a larger student population will receive a comparatively bigger budget than schools with fewer student numbers. It also means the school principal does not have much power over the budget, and therefore, the resources they can acquire, which in turn can have implications on the quality of teaching and learning.

The school contexts described in chapter five (see Section 5.2) showed that despite having similar student numbers (School A - 603 and School C - 593), School C was better equipped with facilities and resources. This implies that while the budget allocated from the MoE to the two schools remained the same (see Section 6.4.3), School C had been able to find means to acquire more funding in order to facilitate the school with more resources. This usually becomes possible under proactive and capable leaders. Research has shown that school leaders who strive for success have a strong vision and strategic direction (Chandra, 2016; Kirkland & Sutch, 2009). They emphasise the development of their teachers as the cornerstone for student success and perceive innovative use of technology as integral to their establishment (Chandra, 2016; Kirkland & Sutch, 2009). Such leaders seek to work outside their formal realm (i.e., MoE) to seek developmental opportunities (e.g., acquire resources or professional development programs) in order to support their teachers (Chandra, 2016; Lawrence & Tar, 2018).

The findings from the current study support Chandra (2016) and Kirkland and Sutch's (2009) views regarding the importance of these leadership attributes for successful technology integration ventures, as described by the participants from School C. According to them (Aanisa, Shidhatha, Raihana), their principal was a strong, purposeful, and visionary leader who was enthused about making his school the most technologically advanced school in the region. Such passion for innovation, they believed, drove their principal to seek assistance from the regional ICT coordinator to work along with him to set up a virtual learning management system (VLMS) for the school (see Sections 5.10 to 5.12). The teachers proclaimed this a remarkable achievement for such a small, community school on a local island. This type of "outward-looking practice," denoted by (Kirkland & Sutch, 2009, p. 5), is crucial to champion innovations. As Chandra (2016) posited, principals are the "gatekeepers of change" (p. 242), and their ability to innovate and lead the school community can affect the success of these school reform agendas (Chandra, 2016).

Professional and Emotional Support

The literature also draws attention to the critical role of school management, especially the principal, in preparing teachers (professionally and emotionally) for their uptake of technologies (Chandra, 2016; Kirkland & Sutch, 2009; Lawrence & Tar, 2018). The interview analysis of teachers from Schools B and C shows that this type of professional and emotional support was crucial to teachers' efforts to adopt technology in their teaching.

All three teachers from School C unanimously agreed that they had full support from the school management, especially the principal (see Sections 5.10 to 5.12). Teachers' experiences of the VLMS implemented at this school, and the principal himself training teachers how to use the system demonstrates how the principal's knowledge of technology and prior experiences can be valuable in providing teachers with the necessary hands-on engagement practices (Chandra, 2016). Consequently, the teachers believed that the guidance they received "especially [during] the PDs on how to use the technology … [the] support [and] encouragement [on how] to use more technology" (Shidhatha) from their principal was the determining factor for the VLMS's success.

Similarly, Anil, Fariyal, and Suma (School B) described their principal's support in enriching teachers' knowledge and skills by making use of every opportunity he had (e.g., professional development days, subject committee meetings) to introduce teachers to new technological innovations they could adopt in their classroom instructions. According to Chandra (2016), the principal's ability to be a role model for teachers can positively influence the staff and build their confidence "because they know that they have an expert who is on-site and someone they can lean on" (Chandra, 2016, p. 243).

The views expressed by these teachers and the literature underline that school leaders need to take on a more proactive role to promote a positive cultural ethos that advocates and supports teachers teach with technology. These findings also depict the inevitable role of school leaders as change agents that motivate and encourage teachers to move beyond expectation in their use of technology for the benefit of their students (Chandra, 2016; Lawrence & Tar, 2018). Moreover, as observed from Schools B and C, the principals' ability to influence others is vital to facilitate the resources teachers need to teach with technology, while the lack of such skills can impede and demotivate teachers' efforts (School A). It also shows how the principal's knowledge and experience of classroom use of technology can vantage teachers with hands-on experiences while offering vital professional and emotional support, especially when embarking on innovative projects (e.g., VLMS) (Chandra, 2016; Kirkland & Sutch, 2009). Thus, any attempt to implement technology in schools must consider the principal's TPACK, as this knowledge will enable principals to appreciate what TPACK truly entails and therefore better manage the critical contextual factors, including school management, resources, and teachers (Chandra, 2016).

6.4.7. Professional development training

The literature, as well as the preceding discussion, has demonstrated the critical role of teacher training and professional development to improve teachers' technology skills and foster positive attitudes towards technology integration (Alt, 2018; Beauchamp et al., 2015; Corey, 2019; Fenton, 2017). The teachers in this study talked at length about the professional development and training and how it affected their knowledge and skills to use technology in their practices. As shown in *Figure 6.6* below, participants acquired knowledge from formal training and through informal platforms.

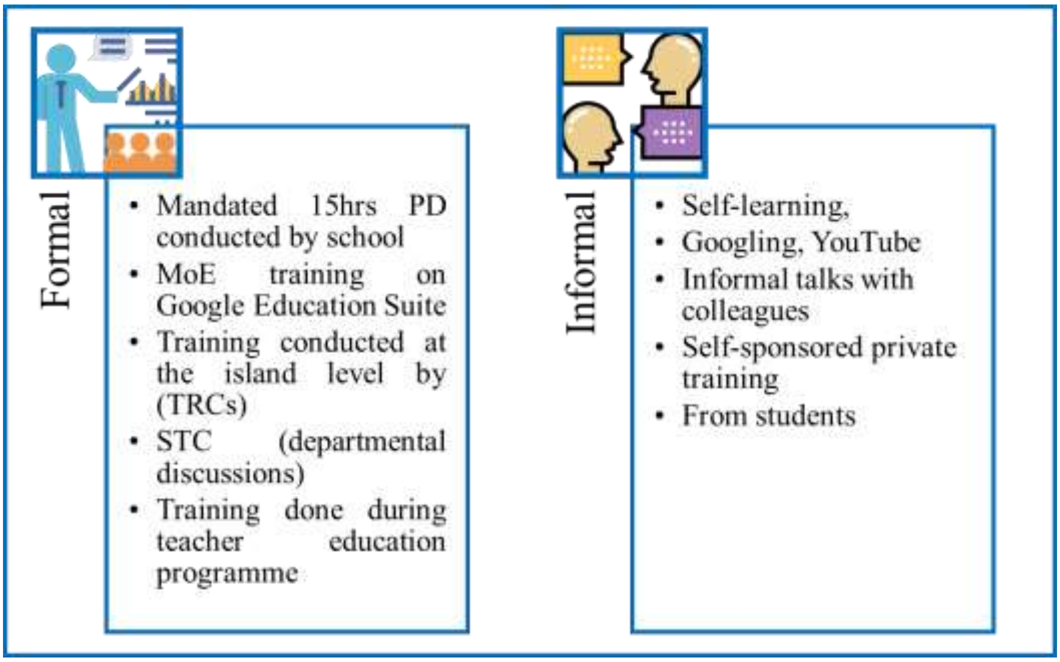


Figure 6.6: Technology related training teachers have undergone in the Maldives

The formal training included various professional development training and workshops organized by the schools, the Ministry of Education, and their teacher education program. The informal means mainly were through their self-learning via YouTube or Googling, informal talks with colleagues, and sometimes from students.

6.4.7.1. Formal training

Although the teachers perceived the formal school-based training they have done to be beneficial, the interview analysis revealed that not all training experiences were perceived positively, nor did they enable teachers to integrate technology in their teaching. For example, while sharing his experiences of training, Ameen recalled a training session where "someone from IT ... gave … training to teachers … from that session … [they] did not know how to do anything using computers" (Ameen). This shows that teachers do not gain much from a 'one-shot' style workshop that is often fragmented and unrelated to their specific context and curriculum (Darling-Hammond & Richardson, 2009). Teachers felt that the mandated 15-hour training provided by the school was not sufficient to meet their PD needs. To elaborate, Anil stated that "only in the PD days [they had training], and that was also very rare … I can say much is not done in that regard … some of the ideas from the outside speakers right, they introduce some of the ideas, but not much … it is not enough". As evident from Anil's statement, these were often one-off sessions where teachers might get introduced to a particular technology without considering the pedagogical application of the technology for teachers' specific subjects (Darling-Hammond & Richardson, 2009). Thus, teachers felt they lacked adequate knowledge and skills to source subject-related content and use technology in engaging ways (e.g., collaborate, differentiate) in their instructions (see Sections 5.4 to 5.12). These findings evidenced that teachers did not perceive the merits of such training where it was deficient in helping them connect the technology knowledge with content and their pedagogy (Darling-Hammond & Richardson, 2009; Mishra & Koehler, 2006).

Another issue participants identified was the time allocated to complete the online training (e.g., Google Classroom). Some teachers felt the training was overwhelming, and they "could not study everything in proper time" (Lirgam). Teachers believed that the time provided was not adequate to grasp everything. Consequently, most teachers had forgotten the content covered in training and rarely applied it in their teaching practice.

These experiences made some teachers realize they preferred facilitated "face-to-face training" (Lirgam) instead of self-paced online training. These feelings mainly emanated from teachers who faced difficulties linking the training to their teaching. Teachers felt that they were not prepared to apply what they had learned in their teaching practice. They needed "long-term training" (Fariyal) support from an expert to demonstrate how they could practically apply the training knowledge into practice. Beauchamp et al. (2015) reported similar findings where teachers requested more classroom-based training to observe context-specific pedagogical applications of iPad use. This explicates the need to focus the training on facilitating teachers' understanding of the relationships between content, pedagogy, and technology and the context within which they work (Mishra & Koehler, 2006). To facilitate teachers making such connections, opportunities to practice hands-on activities to practice and reflect on it with colleagues are crucial (Mishra & Koehler, 2006). Moreover, as evidenced by this study's findings and literature, the training process needs to be intensive and sustained over time (Darling-Hammond & Richardson, 2009).

Figure 6.7 summarizes how formal professional development either supports or hinders teachers use of digital technology to promote effective teaching and student learning. It combined the training practices identified from the current study with works from Darling-Hammond and Richardson (2009). The new findings from the current study are shown inside the brackets.

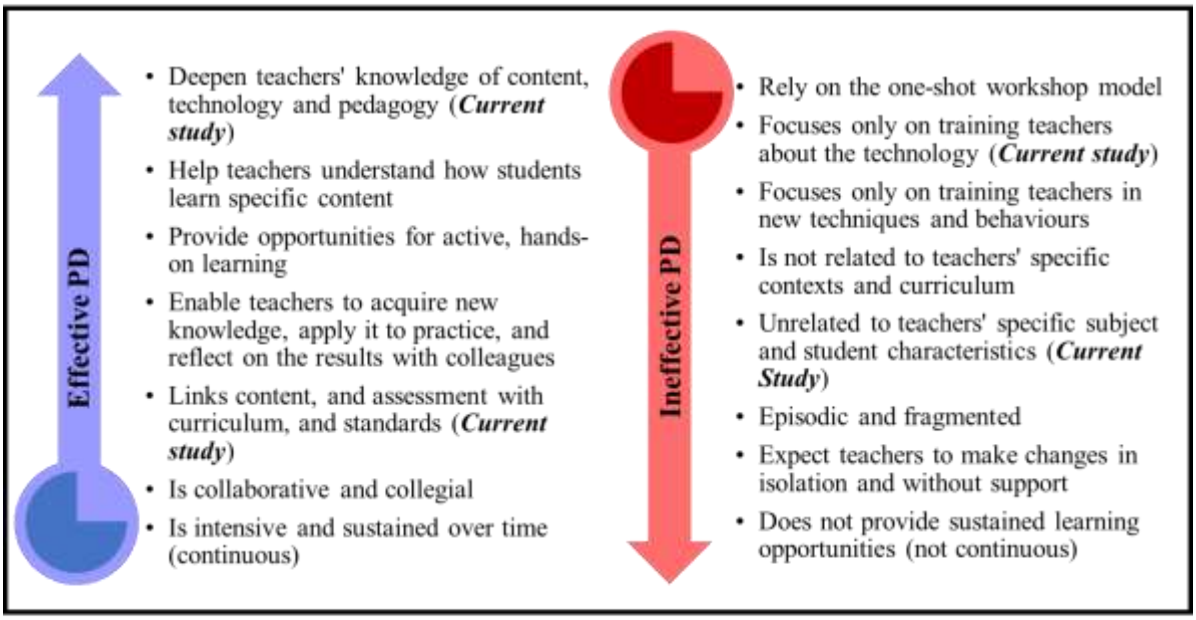


Figure 6.7: Training for teacher professional development (Adapted from Darling-Hammond and Richardson (2009))

6.4.7.2. Informal training

Self-learning

Teachers learning or seeking information through self-exploration (e.g., Googling and YouTube) was evident from all the nine participants in this study. The teachers were aware that their independent learning and exploration were necessary to explore the endless ways technology could be used in their classroom settings. This willingness to move to more informal, self-directed learning observed from the participants was instrumental, as research has proven the benefits of intrinsically motivated learning (Beauchamp et al., 2015). Moreover, when the desire and the drive to learn is intrinsically motivated, the learning becomes more relevant to their own PD needs, and therefore more meaningful since it is related to something teachers want, rather than being forced onto them by their school or the MoE (Beauchamp et al., 2015).

Learning from colleagues

The findings demonstrated that teachers in this study approached their colleagues or vice versa for knowledge and practices with technology. Lirgam, for example, "whenever [he had] doubts, [he] usually Google it or [discuss] … with other friends". Indeed, as Beauchamp et al. (2015) posited, teachers having their network of friends was beneficial as they could share good practices or ask questions from others who already had the expertise to use technology in their classes. For instance, Ameen declared that "… if there [was] anyone knowledgeable, [he]

… contact and learn from them”. This type of learning practice was observed from other teachers too (see Sections 5.4, 5.5, 5.8, 5.9 and 5.11) and shows that the informal interaction with colleagues was a valuable source for acquiring knowledge and skills, which they would not have gained from any formal training.

Darling-Hammond and Richardson (2009) use the term ‘professional learning community (PLC)’ to describe similar types of informal learning structures as described by the participants in this study (Lirgam, Ameen, Fariyal, Suma). PLCs have been increasingly featured in the literature but as a formal model for teacher professional development. PLCs offer the opportunity for teachers to work together to develop and implement more effective instructional practices by engaging in continual dialogue to examine their practice and student performance (Darling-Hammond & Richardson, 2009). Further, they allow teachers to experiment, practice, and reflect on new practices in their specific context and share their knowledge and expertise on concrete tasks such as curriculum enactment, problem-solving around students and their learning, and peer observations (Darling-Hammond & Richardson, 2009). In this informal structure, teachers were more comfortable approaching and clearing doubts without hesitation and even learning by observing their colleagues (see Sections 5.4, 5.6 and 5.8). These findings show that PLCs can offer several benefits in terms of professional development.

Nevertheless, teachers expressed concerns regarding accessing further development opportunities “as they did not have anyone [they] could go to” (Ameen). As Gupta (2016) noted, the school leadership team needs a proactive role in collaborating with sources within and outside the school to identify and direct teachers for training opportunities. Darling-Hammond and Richardson (2009) proposed two very effective PLC strategies to address these issues: ‘Peer observations of practice’ and ‘Study group’.

Peer observations of practice are similar to what was described by Ameen, who mentioned that the school had teachers skilful in technology, from whom he used to "… seek information ... [on] how they prepare lessons [and] check how they have prepared, what they have done". Although Ameen approaching his colleagues was perhaps due to the closeness he must have had with those teachers; this finding shows the benefit of 'peer observation of practice'. Such strategies open up avenues for teachers to learn from each other by visiting their classrooms and providing feedback and assistance (Beauchamp et al., 2015; Hord, 1997). In addition, having critical friend groups or video recording own practice for peer review has been reported in the literature to help teachers improve their knowledge, practices, and effectiveness

(Lustick & Sykes, 2006; Sato et al., 2008; Sherin, 2004). While not identified in the current research, the use of 'Study group' as a form of PLC, where teachers work collaboratively to research and practice strategies and concepts in implementing new ideas, has also been reported to help improve their practices, raise expectations for traditionally underperforming groups, and create relevant and engaging curriculum (Darling-Hammond & Richardson, 2009; Phillips, 2003). These strategies could prove helpful for teachers in the Maldivian school contexts as well.

Learning from students

Interestingly, two teachers (Suma, Fariyal) described how they acquired technology knowledge from their students, which is uncommon in most classrooms. The teachers valued the opportunity to learn alongside their students in this respect and were happy to relinquish their traditional role as knowledge giver and expert, as noted by Fariyal and Suma. Fariyal believed that students were "the best teachers regarding … technology because they are well versed" with it. Suma reiterated Fariyal's view and added that students were "90% better than [teachers] … not only with technology", but also "subject knowledge". It was unexpected to find participants describing a radically different relationship from the traditional learning model whereby teachers are considered the knowledge experts, and students the passive receivers (Beauchamp et al., 2015). Unlike previous studies, an important characteristic observed from the teachers in this study was their willingness to accept that learning is not always from teacher to student but can be a two-way process, but only if the teachers have the wisdom and readiness to accept it.

6.4.8. Parental influences

Very few studies have discussed the influence of parent and community support on a school's technology implementation initiatives or how it affects teachers' integration of technology (Chandra & Mills, 2015; McClure & Pilgrim, 2021; Roussinos & Jimoyiannis, 2019). Nevertheless, the few studies found that parental and community support (e.g., funding to purchase technology resources or hire experts for teacher professional development) significantly impacted the schools' capacity to adopt digital technologies and teachers' ability to integrate them to benefit student learning. This form of parental community involvement was observed from the interviews given by participants in this study.

For example, the Smart TVs in School A and C classrooms and the Smart boards, and projectors in the classrooms at School B, resulted from the school's collective efforts with the parent-teacher association (PTA) and “generous contributions from well-wishers” (Ameen). In addition, anecdotal evidence from teachers and school administrators has shown the crucial role played by the school PTA in the Maldivian schools in seeking funding and identifying and hiring experts in the educational technology field to help with teacher upgrading. These initiatives by the parental community symbolize their willingness to support teacher’s incorporation of technologies for their children’s sake.

Nevertheless, teachers raised concerns as some parents were against technology integration. For instance, Aanisa felt that some parents were unwilling to use technology in their children's classes because they feared its adverse impacts on their children (e.g., misuse, cyberbullying). This suggests that even though most parents had a positive attitude towards the educational potential of technologies, the lack of awareness about the coping mechanisms if their child gets exposed to cyber-bullying, antisocial behaviour, and exposure to inappropriate content impeded parental willingness. Thus, some parents considered technology a “threat [and believed that] traditional way of teaching” (Aanisa) was safer than using technology.

Parental concerns regarding their children's use of technologies, especially the Internet, are not new in the Maldivian school context. Kinaanath (2013) has denoted that parental fear of their children being exposed to inappropriately explicit content has prevented the children from participating in online discussion forums. These findings highlight the importance of creating awareness and educating parents on technology benefits, especially when introducing digital technologies such as Tablets to reap the desired learning benefit of such investments (Kinaanath, 2013).

Similar findings where parental concerns affect teachers' use of digital technologies (e.g., iPad, Tablets) have also been reported in broader international contexts. McClure and Pilgrim (2021) examined teachers' and administrators' perceptions of technology integration after implementing a 1:1 initiative for middle to high school students (grades 3 to 11) in a rural, public school district in the southern part of the United States of America. Among other factors, the lack of parental support (e.g., hesitancy, lower level of technical ability) impacted their children's use of the device. The study recommended filtering (what students can access) and conducting occasional training sessions to educate parents and the community on the benefits of technology and basic support techniques on how they could assist their children in school activities (McClure & Pilgrim, 2021).

Akin to McClure and Pilgrim (2021), to help reduce parental fear and bring them closer to school and their children's work, School C has expanded access to the parents by giving them access to log in, and view their children's work (e.g., report cards and other information, assessment work, their achievements) at any time. Parental access created some sense of security as they can view and "read all the resources which are provided [similar to a] normal classroom" (Aanisa) and keep track of their children's progress. As McClure and Pilgrim (2021) pointed out, this type of access creates the opportunity for parents to get involved and support their children with schoolwork and help to build closer contact between the parent and the school community. *Figure 6.8* below summarizes the key aspects of how parental support (or lack of) influenced teachers' implementation of digital technologies in this study.

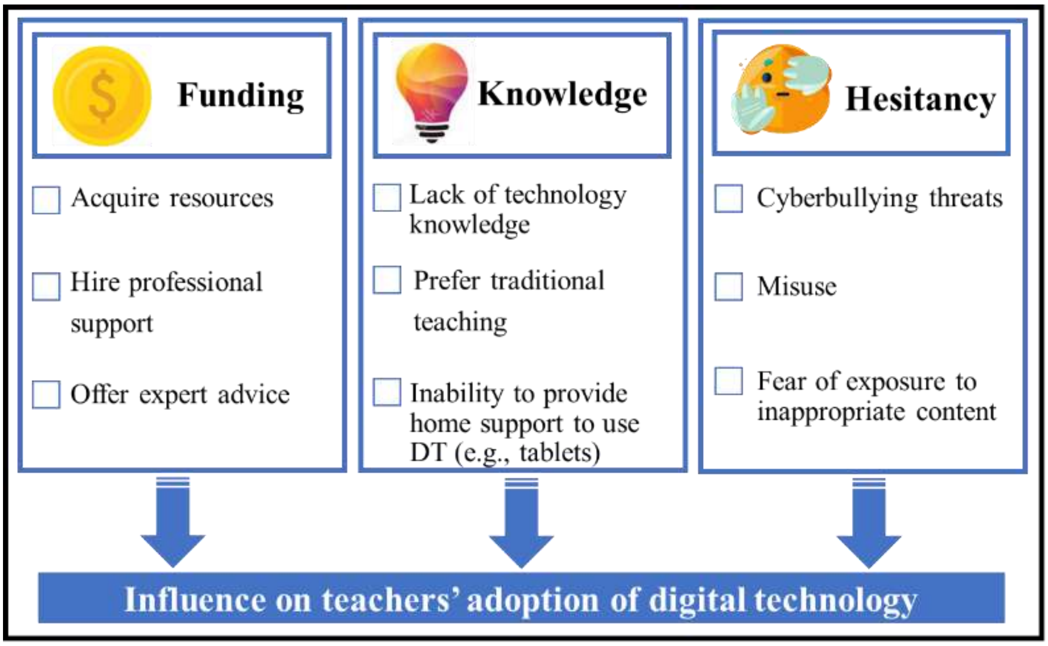


Figure 6.8: The influence of parental community on teachers' integration of digital technology in teaching and learning in the Maldives

6.4.9. National level support

School systems are bounded by the social, political, technological, and economic in which it operates and is affected by the rapid advancement in technologies worldwide (Porras-Hernández & Salinas-Amescua, 2013). The national and global policy directives stemming from these advancements can influence the school and the classroom level factors regarding the technology resources and opportunities available to the teachers and students, and therefore, their technology integration efforts (Porras-Hernández & Salinas-Amescua, 2013).

All the participants in the current study were employed in government schools which meant that they had to abide by their conditions of employment and support. Issues identified from the interview analysis concerning national-level support included the lack of clear policies and guidelines on using the Tablets, lack of access to Wi-Fi in classrooms, lack of adequate training, lack of time (lesson duration), limited access to technology resources, and lack of support from school leadership and technical assistance. One recent example of government policies that had a system-wide impact was the 'Digital School' project. Preparation work the MoE carried out to launch the project included providing Tablets to all the students and teachers in the government schools and training all the teachers from key stages 1 to 4. In addition, the school curriculum (Grade 1 to 12) was (to be) digitized, and the classrooms in all the schools were (to be) facilitated with Wi-Fi access for student and teacher use (Ministry of Education, 2019).

The interview analysis has shown that teachers highly regarded this project and recognised its potential for their teaching and student learning (see Sections 5.6 to 5.9). They even made several plans to conduct teaching and learning activities using the Tablets initially, but could not carry out the activities as planned. The lack of Wi-Fi access inside the classroom and lack of technical support were identified as significant barriers to not using the Tablets to conduct teaching and learning activities (see Sections 6.4.3 and 6.4.4). As a consequence, the teachers' experiences with Tablets were not very optimistic.

Another issue that became apparent from the participants' dilemma centred around the lack of clear policy directives from the national level authorities (i.e., MoE). According to the draft report on the ICT in Education Master Plan 2021-2024, there were no specific ICT guidelines for schools to follow, nor did the schools have any clear digital technologies policies (e.g., use of Tablets) (Ministry of Education, 2021). Therefore, while teachers acknowledged the benefits of Tablets in teaching, this sense of not having clear directions had teachers "[feeling that it] was a waste" (Anil), which prevented many teachers from using it effectively. The lack of clear policies might have been related to the changes in the government (new government sworn in towards the end of 2018) that occurred just three months into the implementation of the project. As a result, the project did not go as planned (Ministry of Education, 2019).

Consequently, participants from all three schools felt that more could be done at the school or even at a national level to integrate the technology. According to Aanisa, although the Ministry had provided Internet initially, "it [was] not working" anymore. The other participants expressed similar issues and believed that they lacked the necessary support from stakeholders to use the Tablets in their classrooms. These findings demonstrate that to engender the possibilities for teachers to innovate their teaching and learning strategies using technologies, especially with large-scale projects, the need to support and adequately fund resources from a national level becomes crucial, especially for government-run schools with limited resources (Salas-Pilco & Law, 2018).

The baseline review conducted in the Maldives to understand the current status (two years since data for the current study was gathered) of technology infrastructure and ICT integration in schools showed that the majority of the schools had access to basic technology resources such as computers and access to the Internet (for teachers), but at very low bandwidths (4 to 8 Mbps). According to the report, only one-third of the schools had technology resources (e.g., Smart TV, Smart Boards or projector for digital presentations) in their classrooms, while just a half of the schools had Wi-Fi access in their classrooms (Ministry of Education, 2019) (see Section 2.4.4). Findings from the current study have shown that almost all the teachers interviewed were unable to use digital technology (e.g., Tablets) inside their classrooms due to the lack of Internet (specifically Wi-Fi) for students to access (see Sections 5.4 to 5.12). The lack of classroom Wi-Fi can limit the teachers' ability to conduct technology-based activities to engage students in learning using digital technology devices (Kozma & Vota, 2014). Thus, if teachers are expected to conduct technology-based learning activities that engage students in meaningful learning as described in the National Curriculum Framework, these critical policy issues need to be addressed at the national level.

The above findings concur with studies done in other SIDS contexts such as Mauritius, Fiji, Papua New Guinea, and Tonga (see Section 2.3) (Kozma & Vota, 2014; Mow et al., 2017; Salas-Pilco & Law, 2018; UNESCO, 2015). A comparison of the significant national-level challenges identified from the numerous ICT in education initiatives in literature and the current study are summarised in Table 6.5 below:

Table 6.5: *National level challenges faced in implementing technology initiatives in schools*

National level technology implementation challenges	**Current study**	**Existing literature**
Lack of funding	✔	✔
Lack of proper building infrastructure	-	✔
Lack of electricity	-	✔
Lack of technological resources (hardware, software)	✔	✔
High cost of hardware and software	✔	✔
Lack of / inadequate Internet, Wi-Fi	✔	✔
Lack of qualified teachers	-	✔

Lack of technology knowledge and skills (school leaders, support staff)	✔	✔
Lack of training for teachers to use ICT	-	✔
Misalignment between teachers’ technology training needs and professional development training conducted	✔	-
Lack of technical assistance staff (IT technician)	✔	✔
Lack of relevant subject-specific content	✔	-
Lack of capacity to maintain ICT in schools	✔	✔
Lack of clear and strategic ICT-guided national level ICT policies	✔	✔
Lack of clear ICT policies at schools	✔	✔
Lack of community inclusion to expand impact and sustainability	✔	✔
Geographical challenges (e.g., remoteness)	✔	✔

The findings in the above table indicate that, despite the specific contexts inherent in different countries, the major challenging factors that impacted the outcome of the ICT in Education policy deliverables and strategies set by the governments did not significantly differ (Salas-Pilco & Law, 2018) except in two areas: (1) professional development training (PDT); and (2) (un)availability of subject-specific content.

With regards to PDT, the interview analysis (see Sections 5.4 to 5.12) and the discussion presented in this chapter (see Section 6.4.7) has shown a mismatch between teachers' perception of the type of training they required, the technology skills teachers need to achieve the goals of the reformed curriculum, and the actual technology training that the authorities (e.g., schools, MoE) provided. As for subject-specific content, the interview analysis has shown that the teachers' use of digital technologies was negatively affected due to the lack of digital content. While this was an issue for all the subjects, it was more pronounced for the two local subjects (Dhivehi language and Islamic Studies). The high subscription charges of online content and teachers' lack of knowledge on where or how to access free content were critical (see Sections 5.4 to 5.12).

Therefore, these two national-level contextual factors related to the Maldivian context are considered unique to the current study. These findings further demonstrate the importance of the government's policy commitment as the first step necessary to ensure the success of technology implementation projects by addressing these barriers to witness real dividends from implementing digital technologies. This must be followed by developing and establishing the necessary mechanisms to raise funds to carry out the implementation plans. It must also be strategically directed with purposeful and proactive leadership (Porras-Hernández & Salinas-Amescua, 2013; Salas-Pilco & Law, 2018).

To summarize, this section identified several factors that influenced Maldivian in-service teachers' integration of digital technologies in their lessons. These concur with existing literature on factors affecting teachers' technology integration in other SIDS as well as international contexts (see Section 2.3) (Afshari et al., 2009; Ali, 2015; Buabeng-Andoh, 2012; Darling-Hammond & Richardson, 2009; Francom, 2020; Hew & Brush, 2007; Lawrence & Tar, 2018; Makhlouf & Bensafi, 2021; McClure & Pilgrim, 2021; Mow et al., 2017; Neira et al., 2018; Porras-Hernández & Salinas-Amescua, 2013; Roussinos & Jimoyiannis, 2019; Spiteri & Chang Rundgren, 2020). This includes factors related to teachers' knowledge and competence, infrastructure, resources and facilities, professional development training, supportive school culture (e.g., peers, school leadership and management, IT technical staff), parental support, and national level support with funding and clear ICT-guided policies.

6.5 A MODEL FOR TEACHERS' INTEGRATION OF DIGITAL TECHNOLOGIES IN TEACHING AND LEARNING IN THE MALDIVES

The Teachers' Integration of Digital Technology in Teaching and Learning (TIDTTL) model (*Figure 6.9*) brings together the findings from this study and the literature. It shows the requirements for teachers to effectively engage students in meaningful learning using digital technologies and the associated influences. The model helps understand teachers' TPACK perception, how technology can be integrated into teaching, and the perceived impact on students' learning (cognitive) engagement. It also helps to ascertain the factors that influence teachers' integration of technologies in their classroom teaching.

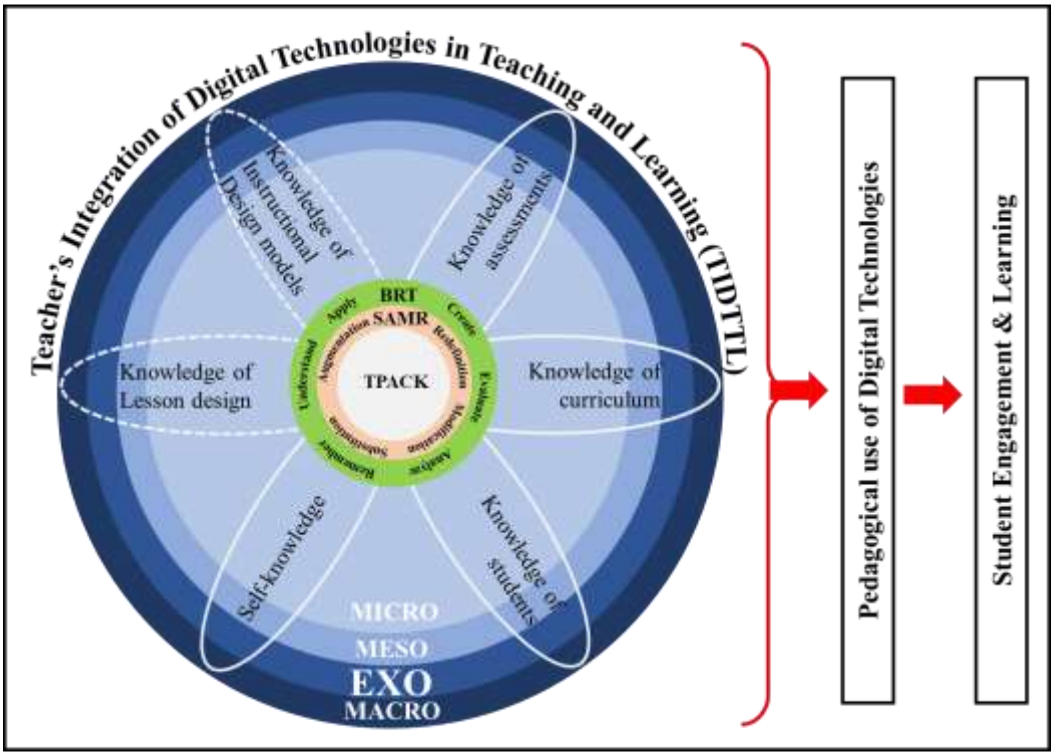


Figure 6.9: Model for Teachers' Integration of Digital Technology in Teaching and Learning in the Maldives (TIDTTL)

The TIDTTL model is based on the premise that teachers' pedagogical practices of adopting technology involve a multitude of factors and are restricted within contextual boundaries. As Mishra and Koehler (2006) argue, conceptualising the nexus of teachers' technology integration practices in such a multifaceted environment can be a complex process. One that requires careful consideration of the amalgamation of the contextual environment and teachers as the knowledge constructor (Porras-Hernández & Salinas-Amescua, 2013). In fact, the literature and the findings from this study have shown that teachers' practices are affected by specific types of influences associated with themselves as the practitioner and their teaching environment and how they are intertwined (see chapters two and six). Thus, the TIDTTL model proposed encapsulates the relationships between these specific influences that shape teachers' pedagogical practices. It is derived by applying the TPACK theory (Mishra & Koehler, 2006), the SAMR model (Puentedura, 2012), and Bloom's Digital Taxonomy (Churches, 2008), as the main theoretical frameworks. The factors affecting teachers' technology integration are categorized into different contextual levels using Porras-Hernández and Salinas-Amescua's (2013) idea of environmental dimensions.

The innermost circle (*grey colour*) in *Figure 6.9* represents the different types of knowledge in terms of TPACK that teachers require for effective technology integration

(Mishra & Koehler, 2006), as discussed earlier in this chapter (see Sections 6.2 and 6.4.2). The teachers' pedagogical practices when adopting digital technologies and their impact on teaching as measured by SAMR (Puentedura, 2012) are shown within the *pink* circle. The *green* circle captures the effect of teachers' technology integration on students' cognitive engagement assessed through Bloom's Digital Taxonomy (Churches, 2008).

Furthermore, as Porras-Hernández and Salinas-Amescua (2013) and many others (see Angeli and Valanides (2009); Chen and Wei (2015)) have argued, this study found that the knowledge teachers required to integrate technology effectively were not restricted to the seven TPACK constructs. Teachers needed knowledge of additional aspects to adapt to the constantly changing condition and working environment (see Section 6.4.2). Thus, the seven *white* ovals connected to the three centre circles (*grey, pink, and green*) denote these knowledge areas teachers require to integrate technology for constructivist-oriented pedagogical practices. The knowledge areas identified from this study and the literature is inside the ovals with solid borders. This includes teachers' self-knowledge, knowledge of students, curriculum (competency-based), and assessments. Teacher's *knowledge of lesson design, and instructional design models* were two knowledge requirements unique to the current study and thus, shown within dotted lined ovals.

The reviewed literature and the findings from this study have also recognised the criticality of the contextual environment in which teachers operate. This environment must be considered as it will affect the transformation of pedagogical practices. Whilst the factors can be internal or external to teachers (see Section 6.4), due to their multilevel and double-directional nature, deliberating the context can be ambiguous, especially if levels are not made distinct (Porras-Hernández & Salinas-Amescua, 2013). In order to make it more explicit in this proposed model, the factors are categorized into four levels: *micro, meso, exo, and macro* contextual levels and are captured within the four circles shaded in *blue*.

The *micro* contextual level refers to the in-class conditions for learning. It includes factors such as teachers' beliefs and expectations, the goals of teachers and students as they interact in teaching and learning activities (Porras-Hernández & Salinas-Amescua, 2013). In addition, the classroom norms, policies, and conditions inside the classroom, such as its design and layout and availability of technology-based learning resources can affect teachers' technology integration at this contextual level.

At the *meso* contextual level, teachers are influenced by the social, cultural, political, organizational, and economic conditions established within the school environment. Thus, the school leaders, particularly the principal's role in facilitating and providing emotional, professional, and technical support, is imminent. The principal's leadership, vision, and strategic direction acquire resources and facilities, ensure technical and other administrative support is crucial. At this level, the support from peers willing to share their knowledge and experiences can also influence how teachers adopt technology (Porras-Hernández & Salinas-Amescua, 2013).

The *exo* contextual level involves the influences teachers' experience from the parents and the outside community. It includes support in the form of expertise or even financial assistance (see Section 6.4.8). However, parents' lack of knowledge and awareness of technology benefits and concern about the harmful effects on their children can adversely affect teachers. The *exo* contextual level is an addition to the contextual level dimensions proposed by Porras-Hernández and Salinas-Amescua (2013). It is uniquely identified in this model due to the nature of effects parents exert on teachers' technology integration that is different from the meso (school community) or the macro environment (broader national or global level) influences.

The *macro* contextual level is defined by social, political, technological, and economic conditions at the national or international level (Porras-Hernández & Salinas-Amescua, 2013). This includes changes in the national and global policies that may stem from the rapid technological developments worldwide, such as the curriculum reform and the 'Digital school' project discussed in this study (see Section 6.4.9).

The TIDTTL model proposed above can be used as a guide to identify the distinct factors and the knowledge teachers require to yield the desired, positive outcomes from technology implementation initiatives. It also offers an avenue for teachers to self-reflect on their knowledge and skills when adopting technologies to conduct engaging and meaningful learning. Thus, stakeholders (school leaders, policymakers) may adopt this model to assess professional development needs to help them adopt technology for effective student engagement and learning, and assess the influencing factors both within the Maldivian or even in other international contexts.

6.6 CHAPTER SUMMARY

This chapter discussed the key significant findings that addressed the research questions explored in the study.

Research question (**RQ1**) one examined Maldivian in-service lower secondary (grades 9 and 10) teachers' perception of the constructs of TPACK (Key Finding #1). Consistent with existing literature, the findings indicated that teachers highly perceived the various constructs of the Technological Pedagogical Content Knowledge (TPACK) framework. However, the findings contradicted previous TPACK studies in that, instead of TK and its related domains, the current study participants' lowest perception was on their pedagogical content knowledge area. Possible reasons for these differences were presumed to be related to the curriculum reform brought in 2014, teacher training qualification and the nationwide technology (Google Classroom) training teachers underwent in preparation for the 'Digital School' project. The discussion on TPACK highlighted two findings specific to the current study: teachers' TPACK variances between nationality and subject discipline. Expatriate (Indian) teachers and teachers who taught English language had higher TPACK perceptions than other groups. However, the qualitative data (interviews and document artefacts from nine participants) did not offer sufficient evidence to substantiate these quantitative results, possibly due to the numerous contextual variances, and led to the second key finding.

Research question two (**RQ2**) investigated how teachers integrate digital technology in their teaching practices, and its impact on teaching and students' cognitive engagement (Key Finding #2). Akin to existing literature, teachers mostly adopted digital technologies such as MS PowerPoint presentations for traditional, teacher-centred pedagogical practices. The adoption of digital technologies in this way resulted primarily in learning enhancement that impacted lower-thinking levels in the cognitive domain. There was a misalignment between their TPACK perception and their use of digital technologies in classroom instructions. This was largely due to the lower perceptions they had on their PCK, TCK, and TPK domains. Thus, a high TPACK perception did not necessarily translate to more constructivist use of technology. However, these findings must be considered with caution since teachers' adoption of technology in this study was measured through qualitative measures. More empirical research comparing teachers TPACK perceptions against their use of technology through quantitative measures may contribute to a better understating of these findings. Besides, the technology integration practices of participants investigated in this study were affected due to several contextual factors, which was discussed under the third key finding.

Research question three (**RQ3**) sought to understand the factors that influenced teachers' technology integration practices (Key Finding #3). Several teacher-related and contextual factors influenced their decisions on when and how they integrated technology in teaching and learning. Teacher related factors included their beliefs and attitudes, knowledge, and competencies, while contextual factors included resources and facilities such as infrastructure, access to software/ hardware resources and facilities, the condition of the available resources and facilities; access to Internet and Wi-Fi; and time, school leadership, culture and community, teacher professional development training, parental and national level support. The complexities and nature of these factors suggested that teachers' knowledge and beliefs and the context they work at had a considerable impact on what was available for them and how it enabled or hindered them from adopting the technology in their classrooms. This chapter has shown that teachers' beliefs and attitudes toward technology must be geared towards more constructivist and student-centred pedagogical practices by educating them on the technological skills needed for these transformative learning practices, focusing on the unattended knowledge domains (PCK, TCK, TPK). Also, before embarking on such ventures, stakeholders must ensure that the contextual factors or the 'first-order' barriers are addressed to make such programs successful.

Chapter 7: Conclusion

7.1 INTRODUCTION

This study explored Maldivian in-service lower secondary teachers' Technological Pedagogical and Content Knowledge (TPACK), their integration of technology strategies, and its impact on teaching and learning. The study also provided insight into the factors that influenced the teachers' technology integration in their teaching and learning. Data gathered from the survey, interviews, and document artefacts provided in-depth understandings of the teachers' decision-making in adopting different digital technologies in their classroom instruction. To achieve this aim, the study sought to address the following research questions:

RQ1: What are Maldivian in-service teachers' perceptions of the constructs of TPACK (Technological Pedagogical and Content Knowledge)?

RQ2: How do Maldivian in-service teachers implement technologies in their classrooms, and what is the perceived impact on students' cognitive engagement?

RQ3: What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

This concluding chapter is presented in five key sections. First, the major findings of this study are summarized (Section 7.2), followed by the theoretical, methodological, and practical contributions (Section 7.3). Next, the study limitations (Section 7.4) and recommendations for future research are presented (Section 7.5), followed by a final summary of the chapter and the thesis (Section 7.6).

7.2 MAJOR FINDINGS

7.2.1. What is the perception of Maldivian in-service teachers' TPACK?

The findings from this study have revealed that in-service teachers teaching in grades 9 and 10 in Maldivian schools, in general, had a high perception of their understanding of TPACK and its related constructs (mean scores 3.93 to 4.65 on a 5-point Likert scale), signifying that they understood and can perform most of the activities indicated in the items of the TPACK survey.

Consistent with previous TPACK studies (see (Koh et al., 2014; Owusu et al., 2015b), the highest perception teachers had was on their content and pedagogical knowledge (see Section 4.3). Also, their perception of TK and other technology-related constructs (TCK, TPK, and TPACK) remained relatively high. The inflated results in these domains (TK, TCK, TPK, and TPACK) might have been a result of the nationwide technology (Google Classroom) training teachers underwent during 2018 (close to the time of data collection for this study) in preparation for the 'Digital School Project", (see chapter two, Sections 2.4.1 and 6.2) where tablets were (to be) given to all students and teachers in government schools.

A contrasting difference was identified in teachers' perceptions of their pedagogical content knowledge (PCK), the lowest across all constructs in this study. Possible reasons for these results might be related to the teachers' lack of understanding of the new curriculum and the large proportion of teachers (11%) without proper teacher qualification (see Section 6.2), issues that have also been highlighted in the Education Sector Analysis report (Ministry of Education, 2019). According to the report, teachers had difficulty conceptualising and applying the competency-based curriculum effectively in teaching. The report also identified issues with lesson planning, especially in schools where the untrained temporary/contract teachers were higher, and supervisory support from the Leading Teachers was lagging. The EASP, 2019-2023 report has proposed several policy strategies to address these issues, but its outcome is yet to be assessed (see Education Sector Plan, 2019-2023 (Ministry of Education, 2019).

Further, this study's evidence showed statistically significant differences in teachers' TPACK against their gender, age, years of teaching experience, nationality, subject discipline, and the frequency of using technology in teaching (see Sections 4.4.1 to 4.4.6). While these differences were negligible for gender, age, and years of teaching experience, the differences were significantly high for teachers' nationality, and subject discipline.

The comparison of TPACK perception against teachers' nationality showed that expatriate teachers scored higher across all the TPACK constructs than local teachers. A possible explanation for these differences might be the teacher recruitment practices where applicants (expatriates) must have a specialised degree in the subject they plan to teach. However, this criterion could not be applied when hiring local teachers (specifically for Dhivehi and Islamic Studies) owing to their lack of qualification (graduate) and unwillingness to work in more remote islands, away from their home and family. Interestingly, although the difference was significant in the survey (see Section 4.4.4), the qualitative data analysis of the teachers from the two nationalities did not offer sufficient evidence to substantiate these TPACK differences (perhaps, due to the low sample size and the various contextual factors affecting teachers) (see Section 6.3). No unique differences were found in how teachers adopted technologies based on their TPACK perception between the two groups, but rather, some teachers, despite having 'very high' TPACK, mostly managed to enhance pedagogical practices (see Section 6.3).

As for the subject discipline, the lowest scores for all the TPACK constructs were observed from Dhivehi Language and Islamic Studies teachers. This was mainly due to the lack of technology application and materials (e.g., subject-based digital text, stories, videos, online applications, websites in the local language) on the two local subjects Dhivehi and Islam. Many applications are designed for children in developed countries, therefore, suited to their curriculum, implying less opportunity for these teachers to adopt technologies in teaching their subjects.

The significant differences in teachers' TPACK perceptions against their nationality and subject discipline have contributed to the literature on TPACK. No studies have reported in-service teachers' TPACK against their nationality or subject discipline, especially on locally developed subjects (Dhivehi language and Islamic Studies) in a developing country context. Thus, this finding offered valuable insights to the current study and contributed to the existing literature on TPACK of in-service teachers in secondary education.

Based on the findings from this study, it can be concluded that Maldivian in-service teachers teaching in grades 9 and 10 have a high perception of the TPACK constructs. The highest perception was on CK and PK, followed by TK and other technology-related domains, with the lowest perception was on their PCK. The study also has evidenced that teachers of local nationality and teachers that taught local subjects (Dhivehi and Islamic Studies) had significantly lower perceptions of the TPACK constructs than other demographics. These findings highlight the areas that need to be focused on when designing professional development programmes to facilitate teachers' technology adoption for classroom instruction.

7.2.2. How do Maldivian in-service teachers implement technologies in their classrooms, and how does it impact students' cognitive engagement?

This study revealed that the most familiar and frequently used technology by Maldivian in-service lower secondary grade teachers (both in the survey and the among the interviewees) was presentation software (e.g., MS PowerPoint). The findings also demonstrated that teachers mostly adopted digital technologies for teacher-centred pedagogical practices of knowledge transmission. These findings concurred with previous studies done in the context of Maldives (Adam, 2015; Kinaanath, 2013) and international contexts (Al Harbi, 2014; Moersch, 2011) who reported that teachers mainly used technology as a presentation tool with little or no hands-on activity for students. Thus, despite teachers' high TPACK perception, teachers mostly adopted digital technologies for teacher-centred pedagogical practices of knowledge transmission that supported lower-order cognitive goals.

In terms of the SAMR model, these findings indicate that for most teachers (Malik, Ameen, Raihana, Shidhatha, Fariyal Lirgam, and Anil), technology integration frequently resulted in enhancement of their practices (Puentedura, 2012), while few teachers (Suma, Aanisa) managed to integrate technology at the transformation level (Puentedura, 2012). Investigation of the TPACK perception of both these groups has shown that teachers who integrated technologies at the enhancement level had a comparatively lower perception of their PCK, TPK, or TCK domains (see Table 6.3). According to Mishra and Koehler (2006), teachers with lower perception in these knowledge domains (PCK, TPK, and TCK) will have lower confidence to leverage technology for different pedagogical activities to facilitate collaboration among students; help them construct different forms of knowledge representations, and plan and monitor their learning. This was evidenced by how the participants leveraged technology in their pedagogical practices and how it affected student engagement. The few teachers (Suma, Aanisa) that did integrate technology more frequently at the transformation level (Puentedura, 2012) engaged students more frequently in activities that fostered higher-level cognitive engagement (Churches, 2008), while those who integrated technologies to enhance their practices (Puentedura, 2012), primarily engaged students at the lower-level cognitive domains of Bloom's taxonomy (Churches, 2008). Consequently, the effectiveness of technology implementation by the majority of the teachers (seven out of the nine participants) in this study can be considered low (Al Harbi, 2014; Moersch, 2011). This shows that teachers need to be supported with the appropriate training on continual basis to leverage digital technologies for effective classroom instruction, not only in technology knowledge but also in all the related knowledge domains (PCK, TPK, or TCK). Further analysis of the interview data indicated that the low level of ICT implementation was linked to a number of other contextual barriers.

In summary, the findings of this study have shown that, simply having 'very high' or 'high' TPACK perception alone may be insufficient if teachers have lower perceptions in other interconnected TPACK domains (e.g., PCK, TPK, TCK) or other factors were affecting this process (see Section 6.4). This finding supported the theory that while technological knowledge is an important domain, the success of technology integration relies on teachers' understanding of all knowledge domains and their interconnections (Mishra & Koehler, 2006). It also indicates that adopting technology for more transformative pedagogical practices requires teachers to be educated not only on the technological skills, but also on developing the knowledge and skills in all the TPACK domains. This, in turn, will enable teachers to adopt technology to engage students in more constructivist-oriented practices that promote meaningful student learning, provided that the school has addressed other contextual barriers.

7.2.3. What factors influence Maldivian in-service teachers' current practice with technology integration in their classroom teaching?

Investigating factors that influenced participants' integration of digital technologies found six broad themes related to teachers and their contexts. These were grouped as 'micro', 'meso', 'exo' and macro' contextual level factors to make them more explicit (see Section 6.5). Porras-Hernández and Salinas-Amescua's (2013) contextual levels guided this process. The 'exosystem' was an additional level introduced into the contextual levels due to the distinctions identified from the different contextual environments in this study.

First, at the *micro* contextual level (classroom level), several teacher-level factors related to their beliefs and values affected their pedagogical decisions when integrating technology in lessons (Adam, 2015; Ali, 2015; Barak, 2014; Hew & Brush, 2007; Kinaanath, 2013; Neira et al., 2018; Spiteri & Chang Rundgren, 2020). The teachers who believed in the benefits of technology, mainly utilised it to save time, make their explanations easier for students to understand, and enhance their teaching (Puentedura, 2012). The lesson objectives, time availability, subject discipline, syllabus content (heavy), and exam-oriented nature of their subject, and student behaviour affected teachers’ beliefs about when and how they integrated technology in teaching and learning. For the majority of the teachers, the main focus of using technology was to support lesson delivery, typically using PowerPoint presentations or videos for more drill and practice and rote learning practices (Adam, 2015; Kinaanath, 2013). At the *micro* contextual level, there was also evidence to suggest that teachers' knowledge regarding TPACK competence (Mishra & Koehler, 2006), curriculum (competency-based teaching, assessment) (Chen & Wei, 2015), and knowledge about students (cognitive abilities and learning styles) (Angeli & Valanides, 2009) affected their technology integration efforts. The study also identified additional knowledge requirements such as lesson planning and instructional design, and national mandates (policies, support, and opportunities available) that affected teachers' ability to integrate technology in classrooms.

Second, at the *meso contextual* level (school level), the professional and emotional support (training and technical assistance) teachers received from the school leadership impacted teachers positively (Afshari et al., 2009; Lawrence & Tar, 2018). Teachers recognized that the role played by their principal in setting a vision and strategic direction for the school, while building a supportive cultural ethos, was paramount in their adoption of technology at their school (Chandra, 2016; Kirkland & Sutch, 2009). However, the lack of technology resources and facilities (e.g., computer systems, Smart TVs, Internet, or Wi-Fi access in the classrooms) adversely affected teachers' use of technology in teaching (Adam, 2015; Chandra et al., 2014; Francom, 2020; Hew & Brush, 2007; Makhlouf & Bensafi, 2021). Also, the limited time allocation (e.g., combat technical problems, classroom management, classroom student numbers, syllabus coverage), especially when having to move from one location to another to access shared resources, affected teachers' decision-making when contemplating to use digital technologies in their lessons (Al Alwani, 2005; Al Harbi, 2014; Al Sulaimani, 2010). At this contextual level, the findings also evidenced that the training conducted by the schools was vital, especially when introducing new technologies (see Section 6.4.7). The principal played a crucial role in encouraging and training teachers. Also, teachers preferred experts to conduct classroom-based training where they could instantly clarify their doubts (Beauchamp et al., 2015). They needed the training to be more active and hands-on, linked to their subject content, assessment strategies, and curriculum standards, and sustained over time (continuous) rather than one-shot style *training* (Darling-Hammond & Richardson, 2009; Mishra & Koehler, 2006). Further, the weekly subject committee meetings and the more informal mediums (e.g., from peers, students) through which teachers acquired knowledge influenced their implementation of technology in classrooms (Beauchamp et al., 2015; Darling-Hammond & Richardson, 2009).

Third, at the *exo* contextual level, teachers were influenced by the parental community (e.g., for extra funding where government support was limited) (Roussinos & Jimoyiannis, 2019). However, consistent with previous studies (McClure & Pilgrim, 2021), parental (some) unwillingness to use technology, mainly due to lack of knowledge and awareness on the potential benefits of educational technologies, coping mechanisms to deal with child cyberbullying, antisocial behaviour, and exposure to inappropriate content impacted teachers' technology integration.

Finally, the numerous national-level policies and strategic directions affected teachers' uptake of technology for pedagogical practices at the *macro* contextual level (national/ international level). Given that all three school contexts in this study were public, they depended on the government (specifically the Ministry of Education) for funding assistance on all operations. As evidenced from the interview data and the reviewed policy document related to ICT in education in the Maldives (see Section 2.4.4) the support and guidance schools receive regarding technology resources and facilities, technology professional development training was inadequate. Therefore, how the national-level ICT policy strategies fed into school-level policies influenced teachers' views on technology integration programs and how they adopted technology in their lessons (Kozma & Vota, 2014; Mow et al., 2017; Porras-Hernández & Salinas-Amescua, 2013; Salas-Pilco & Law, 2018).

To summarize, the factors identified from this study and reaffirmed within literature (see Sections 2.2 and 2.3) have influenced teachers' decision-making process regarding technology implementation in their lessons. Nevertheless, as evidenced, teachers were affected to varying degrees depending on their school context, the subject they taught, teachers' beliefs and attitudes, and competencies. Thus, stakeholders must commit to addressing the barriers to witness real dividends from implementing digital technologies for innovative learning practices.

7.3 IMPLICATIONS AND CONTRIBUTIONS

The findings and conclusions of this study have contributed to the research field on TPACK and teachers' technology integration in terms of theoretical, methodological, and practical implications.

7.3.1. Theoretical contributions

This study is considered timely and significant in the TPACK literature. First, in most TPACK literature, the focus has typically been on pre-service teachers, and mostly in developed worlds or in contexts where technology in schools has been well established (Archambault & Crippen, 2009; Barac et al., 2017; Koh et al., 2014; Owusu et al., 2015b; Schmidt et al., 2009). Second, thus far, no studies have been conducted in the Maldives exploring teachers' TPACK or the factors that influenced teachers' integration of digital technologies in teaching and learning. Thus, the findings from this study enriched the extensive body of research on teachers' TPACK in teaching and learning by focusing on in-service teachers at the secondary school level in the Maldives, a small island developing state (SIDS) context.

This study also offered an opportunity to investigate the relationship between two important demographic dimensions related to TPACK. That is, in addition to identifying teachers' TPACK perceptions, the study added value by comparing the differences in teachers' TPACK perceptions among the different nationalities (local versus expatriates) and from different subject backgrounds (English language, Mathematics, Dhivehi language and Islamic studies), which has rarely been reported within the TPACK literature. Thus, these findings on the TPACK variations related to the two local subjects (Dhivehi language, Islamic studies), in particular, contribute to the TPACK knowledge body stemming from the unique characteristics of a small island developing context such as the Maldives.

Also, the adaptation and validation of the TPACK survey instrument in the Maldivian secondary education context offers teachers, school leaders, and educational policymakers the opportunity to evaluate the training needs and investigate the effectiveness of technology training practices concerning the development of teachers' TPACK. Thus, this TPACK survey instrument may be helpful to assess the impact of technology training programmes for teachers' TPACK development. Also, since the scale items used to assess the teachers' TPACK was generic, the instrument can be applied to assess the TPACK of teachers from other grade levels, pre-service teachers, or even teacher educators.

Further, this study's investigation of teachers' TPACK, their integration of digital technologies, and the factors that influenced teachers' technology adoption are systematic and thorough compared with previous TPACK studies. While numerous TPACK studies have been conducted, they mainly discussed the TPACK constructs separately without considering the influence of TPACK on teachers' technology integration or other influencing factors that enable or inhibit teachers' technology integration efforts. For example, Owusu et al. (2015b) investigated teachers' TPACK, the relationships between TPACK constructs, and how it applied to teachers' technology integration, while Dede (2017) compared teachers' perceived attitudes regarding TPACK and some demographic factors in Turkish schools. Al Harbi (2014) studied teachers perceived TPACK and the factors that influenced teachers' use of technology in Saudi schools. Koh et al. (2014) investigated Singaporean practicing teachers' TPACK against some demographic characteristics. None of these studies comprehensively covered all three aspects (teachers' TPACK perception, how perception affected the adoption of technology teacher-related, and contextual factors that influenced teachers' technology adoption) within one study. This study considered all these complex aspects to understand teachers' conceptualisation of technology integration more clearly within these complex contextual dimensions. Thus, the tri-theory framework combining TPACK, alongside SAMR and BDT in this study, filled this research gap by allowing the researcher to examine how the three models can potentially aid to understand how digital technologies can be adopted for meaningful learning activities to promote higher-order thinking skills in students. In this regard, the study made significant contributions to the literature on TPACK and technology integration.

Essentially, the proposed tri-theory framework (see Section 6.5) of technology integration in teaching and learning (TIDTTL) offers researchers a new perspective to explore and analyse the complexities of technology integration practices in developing country contexts. The use of the TPACK framework to understand the knowledge teachers require to implement digital technologies effectively and the challenges teachers experienced is prominent in existing literature (Angeli & Valanides, 2009; Porras-Hernández & Salinas-Amescua, 2013). This study adds to this understanding by introducing three additional knowledges (*knowledge of lesson design, instructional design models*) teachers require for successful technology integration practices that result in meaningful student learning (see Section 6.4.2). Also, the findings from the Maldivian context resulted in additional contextual levels (*exo context*) to the three levels proposed by Porras-Hernández and Salinas-Amescua (2013) on the factors that influence teachers' use of technology in their classrooms. Therefore, the model proposed for teachers' integration of digital technologies in teaching and learning in the Maldives adds theoretical value to previous models by combining Mishra and Koehler (2006), Puentedura (2012), Churches (2008), Angeli and Valanides (2009), and Porras-Hernández and Salinas-Amescua's (2013) research findings (see *Figure 6.9*).

7.3.2. Methodological contributions

The adoption of an explanatory mixed-method research design in this study is considered a significant contribution to the existing TPACK studies that have adopted the mixed-method design in studying technology integration.

First, although several TPACK literature exists, few studies have used both quantitative and qualitative methods to investigate teachers’ TPACK and technology integration. The few studies that adopted both methods, such as Owusu et al. (2015b), only used exploratory factor analysis to validate the factor structure of the TPACK items, which was done separately on each set of items of the construct.

The current study, however, first validated the scale items of TPACK (through EFA and CFA) for the Maldivian context although the instrument had already been validated in the Singaporean context (Koh et al., 2013). Furthermore, to validate and strengthen the findings, the researcher adopted multivariate analysis with higher significance levels (0.007) when comparing the demographic differences in TPACK. This step minimized Type I error (due to the presence of several dependent variables (seven TPACK constructs), which might have otherwise shown relationships that were not true (Pallant, 2013). Also, the mixed-method design used in this study first triangulated different modes of research methods (survey, semi-structured interviews, and document artefacts) and then combined statistical models such as EFA, CFA, and multivariate analysis and thematic analyses to explore complex phenomena on TPACK perceptions and teachers use of digital technologies. It can thus be claimed that this TPACK study is thorough in data validation, triangulation, and analyses.

This mapping process identified gaps in teachers' TPACK and how they adopt technologies in meaningful ways, which may be used to assist in supporting targeted professional support and learning. Also, the analytical frameworks used (see Sections 3.14 and 6.3) in this study offer a new perspective for mapping teachers' TPACK to how they use technology in teaching and how it impacts students' cognitive engagement. The base model has implications for how teachers' technology integration strategies can be mapped and analysed across different contexts. It can be used to identify individual teachers' PD training needs and derive mechanisms for system-wide support on how best to maximize the effectiveness of technology implementation initiatives.

The model for analysis of factors that affected teachers’ technology implementation also provides an opportunity to ascertain these influences and the additional resources that may be shaping teachers’ efforts. In this way, the model assists in identifying issues that can be targeted for intervention purposes. The issues highlighted will allow for the redirection of the efforts and ensure a closer alignment of digital technologies for what is taught and how it is taught for maximum educational gain. Examples of this thinking are included in the recommendations that follow.

7.3.3. Implications and recommendations for practice

This research has shown that despite having high perceptions on the TPACK constructs, teachers' use of digital technologies mostly enhanced their pedagogical practices of knowledge transmission, resulting in student engagement at the lower levels of the cognitive domains. It also revealed that few teachers with higher TPACK perceptions demonstrated transformative practices that resulted in more constructivist student engagement. Further, teachers' use of technology was challenged due to several influencing factors, and these findings have several practical implications for teachers, school leaders, and national level policymakers.

For teachers

The TPACK framework can help identify teachers' knowledge gaps to teach effectively using digital technologies. Also, the incorporation of SAMR and BDT within the framework offers directions for teachers on how the technology can be adopted based on their lesson objective and their purpose of adopting the technology (enhance versus transform, transmit knowledge versus foster constructivist learning) in the lesson. The four layers of influencing factors (micro, meso, exo, and macro contextual levels) within the model offer the opportunity for teachers to evaluate and reflect upon the kinds of barriers they may face, what possibilities are available to tackle the issue (s), which may help them better prepare to address the challenges. Also, knowing this information can benefit teachers understand their weaknesses and therefore seek professional and emotional support targeted to address the knowledge gaps to:

a) adopt the framework in teaching and learning activities, to transform pedagogy;
b) allow opportunities for students' use of technologies to transform their thinking and learning;
c) foster constructivist-oriented pedagogical design to facilitate knowledge production, instead of knowledge transmission;
d) self-reflect on pedagogical practices, share, and discuss these with colleagues;
e) establish a close connection with parents and guide them on the merits of, and ways to address misuse of technologies

For school principals and policymakers

The education system in the Maldives cascades directly from the national level (government level) to the school level. The government is thus, responsible for facilitating schools with all the necessary infrastructure and support services (e.g., school building, classroom, and technology resources and facilities, student and teacher allocation, curriculum planning, supervision and monitoring, and professional development training support). Therefore, the support school leaders provide to their teachers is directly linked with the support they receive from MoE, which is primarily based on the school size in terms of its student population (see Sections 6.4.3 and 6.4.9). This study identified several school level (*meso*) and national level (*macro*) barriers such as technology infrastructure, resources, and facilities, school leadership, culture and community support, professional development training issues that influenced the shaping of teachers' use of technology for pedagogical practices.

The tri-theory framework (see Section 6.5) proposed in this study could effectively address the issues mentioned above to guide the technology implementation process at all levels. The framework might be used as a foundational model to guide policies related to technology implementation in schools. For example, embracing the tri-theory framework in the planning process will be helpful to understand the knowledge requirements for teachers to implement technology effectively in their teaching and how they might develop this knowledge. The influencing factors at the four contextual levels could help teachers and stakeholders evaluate where teachers may face barriers and how these could be tackled to implement technology initiatives successfully. Moreover, using the framework to introduce innovative technologies to teachers by focusing on subject content and pedagogical affordances could prove beneficial as it offers a practical hands-on method of applying their knowledge to actual classroom practice. Thus, the proposed model may be used by school leaders and national level policymakers to:

a) develop comprehensive ICT policies and ensure that teachers, students, and parents are well informed on the policies;

b) provide support for teachers as they implement the training content and ensure that the support is sustained throughout;

c) assess and address the factors related to infrastructure, technology support and ICT policy-related issues at the school level to minimize the influence of these factors (e.g., resources and facilities, syllabus content, assessment structure, time allocation, facilitate subject-specific technologies and training);

d) facilitate appropriate professional development training for teachers, school management, IT support staff, and school leaders. One model that can be used for this would be the tri-theory framework proposed in this study which included TPACK, SAMR, and BDT as a guide;

e) to reduce the burden on teachers from having to undergo training, allocate time for training during work hours and introduce measures to evaluate and follow-up on the training;

f) create avenues for teachers to observe models of best practices in using technologies where they get more active, and hands-on learning experiences to help them acquire new knowledge, apply it to practice and reflect on the results with colleagues;

g) facilitate a more collaborative and collegial approach to training through professional learning communities to target groups of teachers instead of providing individualized assistance. This will help empower teachers to lead and become role models to other colleagues regarding using technology;

h) ensure that training is intensive and sustained over time (continuous);

i) target technology training to teachers' specific subject to help deepen their knowledge of content, technology, pedagogy, and how students learn specific content. The focus should be to aid teachers to make appropriate connections between the content, the assessment, and the key learning areas and competencies of the curriculum;

j) create opportunities for teachers to gain adequate experience on different instructional design models, lesson planning, and creating or modifying learning materials (content) they could use to teach with technology;

k) facilitate teachers identify/develop subject-specific digital content; especially for Dhivehi language and Islamic studies where the technology resources and materials for these two subjects are scarce in the Maldives;

l) implement strategies for teachers to obtain teaching qualifications before they join the profession to help improve teachers' pedagogical content knowledge;

m) support teachers by increasing parental awareness on the merits of and threats of technology to their children;

n) facilitate teachers establish a close connection with parents to guide them on the merits of and ways to address misuse of technologies; and
o) promote a culture of research and reflective practice to enhance pedagogical practices.

For teacher training institutions

The findings from this study implicates that teacher education programmes should move away from teaching technology as a separate module, as Koehler and Mishra (2009) posited. Every effort must be made to consciously help pre-service teachers teach with technology in an integrated manner instead of teaching just one technology-oriented course focussed on technological skills by:

a) embedding technology training within all modules throughout the teacher education courses;
b) modelling and providing practical hands-on experiences on how content, technological and pedagogical skills can be integrated and connected to the specific teaching contexts;
c) strengthen the relationship between teacher education institutions and schools.

For other similar SIDS contexts

Although this study's contribution primarily lies within the Maldives as a SIDS context, the proposed recommendations can be applied to other SIDS contexts as there are many similarities among the different nations in terms of the geographical disparities, size, funding capacity, infrastructure, human resources, training and ICT policies (see Sections 2.3 and 6.4). Thus, the tri-theory framework (TIDTTL, see Section 6.5) proposed in this study could be used as a foundational model to guide policies related to technology implementation in schools in these SIDS contexts.

The model can be used to support teachers achieve improvements in students' cognitive engagement through enhanced use of technology tools for higher-order thinking. Essentially, the model accentuates two vital aspects for successful technology integration: teachers' knowledge and skills and contextual factors impacting their technology integration. Henceforth, the recommendations for practice outlined earlier (for teachers, school principals, policymakers, and teacher training institutions in the Maldives) can be followed by teachers and educational policymakers in other SIDS, considering their inherent similarities, as highlighted above. Thus, the proposed tri-theory framework and the recommendations provided in this study adds value to current literature on teachers' TPACK and technology integration in general, specifically in SIDS.

7.4 LIMITATIONS OF THE STUDY

As with any human endeavour, this study and the findings reported are not without limitations. While some of these limitations were related to the methodology, and the data gathered, others were related to the contexts of the participants.

As evidenced from the survey findings (see chapter four), Maldivian in-service teachers had a high perception of the TPACK constructs. According to Schmid et al. (2021) survey data when reliant on self-report questionnaires, can sometimes be misleading due to 'response bias', especially if teachers are unaware of their lack of competence. Thus, while surveys are useful for gathering large amounts of data, they cannot account for under or over self-estimating capabilities (Abbitt, 2011). To minimize these weaknesses, a large sample size (n = 485) and other data collection methods (interview and document artefacts) were used. Also, the survey instrument used to gather data on teachers' TPACK was first pilot tested, and a rigorous factor analysis procedure was done to ensure their validity through EFA and CFA for the Maldivian context. This resulted in a similar factor structure (seven TPACK constructs) and high Cronbach alpha coefficients (above 0.7 for all the items).

In addition, the use of qualitative data (interviews and document artefacts) from case studies of nine participants helped shed some light on the issues noted in the questionnaire. It allowed the researcher to triangulate the survey findings to provide in-depth nuances and expand the descriptions relative to teachers' specific backgrounds. It also helped ascertain teachers' TPACK perceptions against their use of technology and the contextual factors that influenced them. However, a limitation of case studies is the limited number of participants. As mentioned, the qualitative findings were based on nine participants, which might have constrained the unit of analysis and thus impacted the transferability of the findings to other similar contexts.

Another major limitation faced with qualitative data in this study was the limited number of document artefacts (e.g., lesson plan, sample task/activity/assessment, student work). Artefacts were not received from all the nine participants (due to school closure from the COVID pandemic, some teachers could not access their materials). The shared documents were also minimal, and therefore, the researcher could not make meaningful analysis from the documents, which is considered a significant limitation in triangulating the interview findings against their actual pedagogical practices.

The use of the SAMR model in this study is acknowledged as another limitation. It has been criticized for its simplicity and lack of published literature on its use to determine the degree of transformation resulting from technology us (Hamilton et al., 2016). Nevertheless, it has been increasingly used in the education sector as a descriptive model for teacher practice and research contexts (Blundell, 2017; Hilton, 2016). Thus, when interpreting how teachers adopted technologies based on SAMR, the researcher adopted an assessment tool based on Blundell (2017) and others (Cherner & Curry, 2017; Puentedura, 2012, 2014a, 2014b; Thornton, 2017) to measure the degree of transformation (see Appendix Q).

Also, since the conditions under which these teachers operated varied based on their school contexts, generalizing from the case studies may not be prudent, but considering that all three schools depended on the government as the primary source of support, it can be safe to assume that what was found among these teachers could also pertain to the rest of the government schools in the Maldives. However, since the participants were selected purposely based on their volunteering, their school location, and TPACK perception scores (see Section 3.12.2), the researcher caution readers when interpreting the case study findings.

Lastly, the timing of the data collection is noted as a limitation of this study because it was just three months into the implementation of the 'Digital school' project where Tablets were introduced to schools. This might not have allowed teachers sufficient time to understand or utilise the device to gain maximum benefits from teaching their subject. Thus, the participants' opinions on the Tablets' experiences reflect their thoughts at that point in time. This indicates an opportunity for further research to understand their opinions now (two years into implementing the project). In light of these limitations, the researcher cautions readers when interpreting the findings presented in this study. For similar reasons, the identified factors should also not be considered definitive but indicative.

7.5 SUGGESTIONS FOR FUTURE RESEARCH

Although the current study has made every effort to provide a comprehensive understanding of technology integration by in-service teachers in the Maldivian lower secondary grades, it has been limited in many aspects, as indicated earlier in this chapter. Thus, future researchers could tap into a number of areas to further enrich the literature on teachers' knowledge and understanding of TPACK and technology integration for the Maldivian and international contexts.

First, the nature of the data collected can limit the findings and conclusions of a study. In this study, qualitative data were gathered for the second phase (qualitative case studies), and was mainly based on teacher interviews and documents artefacts and was used to identify how teachers integrated technologies and the factors that influenced their efforts. The findings reported were based on their self-awareness and their ability to recount their teaching approaches and behaviours. Thus, the description of how they used technology and the challenges they experienced may have been shaped by each teachers' beliefs and attitudes, their predispositions, and subjective biases. This could have been significantly reduced with observation data (Merriam & Tisdell, 2015). Against this backdrop, the researcher suggests future studies to consider these two (conducting observation and gathering adequate document artefacts) to ascertain and corroborate the findings from the interview.

Second, teachers' narratives to understand the influences that affected their integration of technologies within their school context also limit the findings as those factors were unique to the group of teachers who participated in the interviews. Thus, a larger scale quantitative study can be conducted to get a more comprehensive status of the factors influencing teachers across the country. Future studies could refine or create quantitative instruments to measure the aspect of teacher-related factors (belief and attitudes, technology knowledge and competencies) and contextual factors (access to resources and facilities, technical support, time limitations, leadership and training support, support from parents and national level support) particularly in the context of developing countries. These types of data can be helpful to really compare the variables against each other to understand which factors are most critical for successful technology integration. This will give the reader and the researcher a broader understanding of how teachers are influenced in their technology integration efforts across the country.

The third interesting area to explore would be the impact of technology use on student performance. While the current study focused on the impact of teachers' use of technology on students, it approached this by examining how students were impacted in terms of their cognitive engagement, and this was mainly done based on the interview data gathered from participants. It will be interesting to observe the effect of actual classroom activities on student engagement or compare the type of technology-based activities conducted by teachers against the student's performance data. Thus, as the ultimate goal of integrating technologies is to improve student learning, future researchers may compare these variables by observing students while engaging in classroom activities, analysing work produced by students, or their actual performance results.

The findings reported in the current study were based on data gathered at one point in time. Thus, they are not helpful in ascertaining the effects of technology implementation projects such as the 'Digital School' project that was implemented in 2018. Determining this could be beneficial in understanding the benefits of such projects, especially for stakeholders at the policy-making levels that work to seek funding for such projects. Thus, further research might contemplate longitudinal studies such as a pre-post design or even action research to detect changes over time (before and after implementing any technology project). The tri-theory framework proposed in this study can be adopted for such projects. This can be done as a pre-post design (gather data at the beginning of the programme and then at two or more times in the future) to compare the data and look for patterns in the effectiveness of the professional development program. For example, prior to professional development training, the model can examine teachers' TPACK perception. This can be followed with training on adopting digital technology in ways that engage students in higher-order cognitive activities (using SAMR and BDT). Following the training, post-assessments can be done to compare the pre-post data on teachers' TPACK perceptions.

Finally, the model proposed in this study can be applied to the teachers in the current context and can also be adopted when conducting professional development programmes for pre-service teachers, primary, middle school, higher secondary grade teachers, teacher educators, and even to students. Thus, it will be interesting to see future research adopting this model to explore teachers' TPACK, their use of technology, the perceived impact on student engagement, and the factors influencing the technology integration efforts in any of these levels, both in the Maldives, other SIDS or even in international contexts.

7.6 SUMMARY OF THE CHAPTER AND THE THESIS

This study investigated teachers' TPACK perception and their integration of digital technologies in teaching and learning in grades 9 and 10 in the context of a small island developing state (SIDS), the Maldives. An explanatory mixed-method research design was adopted to gather quantitative survey data on teachers' TPACK, followed by qualitative interviews and document artefacts. The aim was to understand teachers’ TPACK perception, how they integrated technology, the perceived impact on students' cognitive engagement, and the factors that influenced their technology integration efforts. A tri-theory framework comprising the TPACK model (Mishra & Koehler, 2006), the SAMR model (Puentedura, 2012), and the BDT (Churches, 2008), and the contextual levels proposed by Porras-Hernández and Salinas-Amescua (2013) formed the theoretical basis of the investigation.

Consistent with existing literature, the Maldivian in-service teachers perceived highly on TPACK constructs (Koh et al., 2014; Owusu et al., 2015b). However, unlike previous studies, the teachers' perception of the pedagogical content knowledge was the lowest. Two valuable contributions to the TPACK literature were the comparison of teachers' nationality and subject discipline that has shown that local teachers and those who taught Dhivehi language had significantly lower TPACK perceptions than other groups. Nevertheless, the qualitative data analysis did not offer sufficient evidence to substantiate these differences, mainly due to limited samples (nine interviewees) and the numerous contextual variances among the teachers interviewed.

This study demonstrated that teachers mostly used technologies such as presentation software to enhance their pedagogy for traditional, teacher-centred practices to engage students at the lower levels of the cognitive domain in Bloom's taxonomy. An important finding from the study was that having a high TPACK perception did not have any bearing on the frequency of technology use or for more student-centred, constructivist use of technology, primarily due to the lower perception of PCK, TCK, and TPK domains. According to Mishra and Koehler (2006), to help students understand their subject content and promote high-order thinking using digital technologies, teachers need to interpret their content knowledge, explore alternative strategies and tailor the instructional materials to suit students' needs based on their prior knowledge (Shulman, 1987).

The study has also found several factors that affected teachers' adoption of technologies, akin to Porras-Hernández and Salinas-Amescua’s (2013) model of contextual levels. This included teachers' beliefs and attitudes, knowledge, and competencies (at *micro* contextual level), issues with school infrastructure, resources, facilities, Internet and Wi-Fi, time, school leadership, culture, and community, and teacher professional development training (at *meso* contextual level), parental factors such as funding support (e.g., PTA support to facilitate school's technology implementation initiatives) and their beliefs about their child's use of technology (e.g., fear of adverse impacts such as misuse, cyberbullying) (at *exo* contextual level), and governmental support in addressing barriers (e.g., guidance and clear direction on ICT policies, support with facilities and resources, adequate time allocation, teacher qualification, and technology professional development training) (at *macro* contextual level).

To conclude, the findings and the tri-theory framework proposed by this study offer valuable information on teachers' TPACK, which is necessary for the meaningful adoption of technology in teaching. The framework can be beneficial for key stakeholders (teachers, school leaders, and management, teacher education trainers, and education policymakers) in the Maldives in identifying the challenges in the system that must be addressed when embarking on educational reform programs; especially where large scale technology implementation initiatives are conducted. It has also identified the areas that must be focussed on when training teachers for technology implementation initiatives. Thus, the findings and the model proposed in this study may be adopted by teachers, schools, and other stakeholders to target resources and aid teachers in the effective use of technology for meaningful student learning.

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Appendices

Appendix A

Studies on factors affecting teachers' integration of digital technologies in teaching and learning

Author	Context	Major findings	Title
Afshari, Bakar, Luan, Samah & Fooi (2009)	Theoretical paper	Identify the factors as manipulative (e.g., ICT Vision, Accessibility, Time, Training) and non-manipulative (e.g., educational level, age, gender, educational experience) factors	Factors affecting teachers' use of information and communication technology.
Ali (2015)	Quantitative survey of 373 lower secondary school teachers in the Maldives.	Explored the factors that facilitate the use of technology in teaching practice among lower secondary teachers of Maldives. Participants inclined to have a traditional pedagogical belief. Females use technology in traditional context while the males show constructivist use technology. Teachers trained in local institutes tend to use technology more traditionally compared to teachers trained from overseas. Need for continuous PDP in all schools. Teachers above 40 years tend to use technology for students learning compared younger teachers.	Factors that facilitate the use of technology among secondary teachers in Maldives.
Bingimlas (2009)	Meta-analysis	The findings indicate that teachers had a strong desire for to integrate ICT into education; but that, they encountered many barriers. The major barriers were lack of	Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature

		confidence, lack of competence, and lack of access to resources	
Buabeng-Andoh (2012)	Literature review	Identifies personal, institutional & technological Characteristics	Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature.
Ertmer (1999)	Theoretical paper	Describe both the first- (incremental, institutional) and second-order (fundamental, personal) barriers that hinder teachers' technology implementation efforts	Addressing first- and second-order barriers to change: Strategies for technology integration
Francom (2016)	Quantitative survey. 1,079 K-12 teachers in a rural North Midwestern state	Teachers in smaller districts reported more access to technology tools and resources and higher administrative support for the use of technology than did teachers in larger districts and communities. Teachers in larger districts and communities reported higher time to plan and prepare for technology integration	Barriers to technology use in large and small school districts.
Francom (2020)	K-12 public schools in a North Midwestern US	Key factors include: access to technology tools and resources, training and tech support, time, technical support, support from principals and other school administrators, culture, teacher and beliefs	Barriers to technology integration: A time-series survey study.
Jones (2004)	A review paper of existing studies plus a survey of 170 teachers and practitioners in the UK	Review of actual and perceived barriers to the uptake of ICT by teachers. Identified factors includes: levels of access to ICT, inappropriate training styles, lack of to fully prepare and research materials for lessons using ICT, technical faults with ICT equipment, resistance to change, teachers' belief about the benefits, teachers' gender has an effect on the degree to which they use ICT, age does not have an effect,	A review of the research literature on barriers to the uptake of ICT by teachers.

Kirkland & Sutch (2009)	Literature review	Draws on existing literature to identify existing barriers to innovation in schools which was categorised under innovation, informal and social support structures, formal environment, risk aversion, leadership, shared vision, and change management.	Overcoming the barriers to educational innovation: A literature review.
Kopcha (2012)	Intervention study Mixed-methods study. Survey, interviews, and observations conducted with18 elementary school teachers in USA	Examined teachers' perceptions of the barriers to technology integration (access, vision, professional development, time, and beliefs) and instructional practices. Situated professional development activities helped create an environment that supported teachers' decisions to integrate technology	Teachers' Perceptions of the Barriers to Technology Integration and Practices with Technology under Situated Professional Development
Lawrence & Tar (2018)	Qualitative approach. Six university teachers from Nigeria	Identify the factors that influence teachers' decision to adopt and integrate ICT in teaching and learning process. The identified factors include teacher-level, technological- and institutional-level factors.	Factors that influence teachers' adoption and integration of ICT in teaching/learning process.
Makhlouf & Bensafi (2021)	Mixed-methods study. Secondary school EFL teachers in the Western District of Chlef toward ICT use in Algeria. Survey 50 and interviews 6 participants	EFL teachers held positive attitudes toward ICT in education. There were statistically significant positive correlations between teachers' attitudes toward ICT and the five aforementioned independent variables. It was also found that age and academic qualification had negatively correlated with attitudes.	An exploration of factors influencing teachers' attitudes toward the use of information and communication technology (ICT) in classroom practice: A case study of secondary school EFL teachers in the western district of Chlef , Algeria.
Neira Ibáñez & Crosetti (2018)	241 teachers from different educational institutions in Colombia	Perceptions of the teachers from on the factors that facilitate or limit the incorporation of Emerging Technologies in the classroom. Identified four different contextual levels (microsystem, mesosystem, exosystem and macrosystem). Motivation, infrastructure and information and communication	Factors that facilitate or limit the incorporation of emerging technologies in the classroom.

		technologies skill, government policies or strategies, infrastructure, as well as training plans were found as important factors.	
Porras-Hernández & Salinas-Amescua (2013)	Theoretical paper	Obtain dense descriptions of concrete experiences in the use of ICT and factors that influence their practice. Discussed the factors in terms of ‘scope’ and ‘actors. Scope includes three contextual levels (macro, meso and micro) and actors included teachers and students.	Strengthening TPACK: A broader notion of context and the use of teacher's narratives to reveal knowledge construction.
Roussinos & Jimoyiannis (2019)	Quantitative survey with 360 in-service primary education teachers in Greece.	Perceptions of teachers’ knowledge and skills with regards to the integration of ICT in instructional practices. Efforts to implement ICT-based interventions in their classrooms could be affected by factors related to the educational context in the Greek primary schools.	Examining primary education teachers’ perceptions of TPACK and the related educational context factors.
Shameem (2016)	Quantitative survey 288 teachers (grades 8-12) from 9 schools (Jordan, Maldives, and the United States)	Explores the influence of culture on teachers’ attitudes towards technology beyond the established factors. Significant differences in attitudes toward technology between the teachers in the nine schools	Influence of culture on teachers' attitudes towards technology. Lehigh University.
Spiteri & Chang Rundgren (2020)	Literature review	Factors affect primary teachers’ use of digital technology in their teaching practices. Four influencing factors were identified: teachers’ knowledge, attitudes, and skills, which are also influenced by and influence the school culture.	Literature review on the factors affecting primary teachers’ use of digital technology.

Appendix B

Studies on TPACK Scale development and TPACK perception

Author	Context	Methodology	Major findings	Title
Abbitt (2011)	Pre-service teacher (USA)	Quantitative Review paper	Reviewed the methods and instruments to assess TPACK understanding among pre-service teachers	Measuring Technological Pedagogical Content Knowledge in Preservice Teacher Education: A Review of Current Methods and Instruments
Altun & Akyildiz (2017)	Elementary student teachers Turkey	Quantitative 609 final year (fourth grade) student teachers	Average (around 3) TPACK on a scale of 1 to 5 Females had sig higher PK STs with a PC & internet access had sig higher TK CK of for Elementary, Science, and Turkish sig higher than Social Science PCK, TCK and TPACK of Elementary Teaching higher than the other subjects No sig. difference between STs' subject specialism and their TPK	Investigating student teachers' Technological Pedagogical Content Knowledge (TPACK) levels based on some variables.
Archambault & Barnett (2010)	On-line teachers (USA)	Quantitative 596 in-service K12 teachers, virtual schools in America	EFA CFA resulted in 24 items and 3 factors - pedagogical content knowledge, technological–curricular content knowledge, and technological knowledge Cronbach's alpha for the scales 0.89 to 0.70, and internal consistency - 0.94,	Revisiting technological pedagogical content knowledge: Exploring the TPACK framework.
Barac, Prestige & Main (2017)	University Educators (Australia)	Mixed-method 219 teachers	CK was the highest followed by PK and PCK. TK was the lowest All the means were above 0.3 TK, PK, TPACK components and TPACK summary subscales sig. positively correlated with all other scales and subscales	Stalled Innovation: Examining the Technological, Pedagogical and Content Knowledge of Australian University Educators.
Bonafini & Lee (2021)	Pre-service secondary mathematics teachers (USA)	Qualitative study of teacher created screencast video lessons using iPads	Effective use of pedagogical techniques and the screencast app as an amplifier tool, according to the amplifier-reorganizer metaphor	Investigating Prospective Teachers' TPACK and their Use of Mathematical Action Technologies as they Create Screencast Video Lessons on iPads

Castéra, Marre, Yok, Sherab, Impedovo, Sarapuu, Pedregosa, Malik, & Armand (2020)	Teacher educators (multi-nationality)	Quantitative, 574 university teachers from eight institutions across six countries	Seven-factor model after EFA and CFA internal consistency (> 0.8), except for the PCK factor (between 0.6 and 0.7)	Self-reported TPACK of teacher educators across six countries in Asia and Europe.
Chai & Chin-Chung (2010)	Pre-service, secondary teachers (Singapore)	Quantitative Pre-course (n=439) post-course (n=365)	TK, PK, CK and TPACK enhanced after the course, large effect size of 0.65 for CK, 0.69 for TPACK, TPACK sig. and positively correlated with TK, PK, and CK for both the pre-course and post-course Highest predictor was PK, TK also did enhance after training CK remained consistent	Facilitating Preservice Teachers' Development of Technological, Pedagogical, and Content Knowledge (TPACK).
Chai, Koh, & Tsai (2011)	Pre-service (Singapore)	Quantitative 214 Singaporean pre-service teachers	EFA, CFA done, validated, 8 factors CK1 CK2, TK, PK, PCK, TCK, TPK and TPACK Cronbach alpha for 8 factor model - 0.95 Cronbach for individual factor - 0.84 to 0.94	Exploring the factor structure of the constructs of technological, pedagogical, content knowledge (TPACK).
Chaipidech et al., 2022	In-service science teachers (Thailand)	Quantitative survey	In-service teachers who attended the program improved in all knowledge related TPACK Proposed a new model for integrating andragogical principles and personalized learning	A personalized learning system-supported professional training model for teachers' TPACK development
Chen & Wei (2015)	In-service Chemistry teachers (China)	Qualitative 5 teachers	PCK of teachers was a constant factor that led to their adaptations of curriculum materials	Examining chemistry teachers' use of curriculum materials: in view of teachers' pedagogical content knowledge
Graham, Burgoyne, Cantrell, Smith, St Clair & Harris (2009)	In-service science teachers (USA)	Mixed-method design with pre-post survey 15 in-service teachers	Significant improvement between pre and post scores on all of the TPACK constructs, with greatest level of confidence in their TK, followed by TPK, then TPACK, and finally TCK	Measuring the TPACK confidence of in-service science teachers.
Harris & Hofer (2009)	School teachers (USA)	Qualitative	Proposed activity-based instructional planning strategies that align learning activities with educational technologies to develop comprehensive, curriculum-keyed taxonomies of activity types that incorporate content, pedagogy, and technology knowledge and their intersections.	Instructional Planning Activity Types as Vehicles for Curriculum-Based TPACK Development Society for Information Technology & Teacher Education International Conference 2009, Charleston, SC, USA
Jang & Tsai (2012)	Elementary mathematics and science teachers’	Quantitative survey-based questionnaire	Significant differences in the TPACK of elementary teachers who used IWBs compared to teachers who did not use IWBs. Science	Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards

	use of IWBs. (Taiwan)		teachers demonstrated significantly higher TPACK than mathematics teachers.	
Jang & Tsai (2013)	In-service science teachers (Taiwan)	Quantitative 1145 from 123 schools	Four factors identified, Cronbach's α - overall TPACK - .959. TPACK was above average. TK and TPCKCx lower than CK and PCKCx. Sig diff with male rated higher TK than females. CK and PCKCx higher for experienced teachers. TK and TPCKCx higher for less experienced teachers	Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model.
Kim et al., (2021)	US, China, India, Australia, and South Korea	Collective case study review of AI education resources, guidelines, and curricula	Teachers who teach AI to K-12 students require TPACK to construct, prepare an environment, and facilitate project-based classes that solve problems using AI technologies	Analysing Teacher Competency with TPACK for K-12 AI Education
Koh, Chai & Tsai (2014).	Practising teachers, primary and secondary (Singapore)	Quantitative 354 practicing teachers	Seven factors after EFA and CFA. Cronbach alphas above 0.90 for the 7 constructs, and overall Cronbach alpha of 0.96 TPACK perception: above average for all the TPACK categories with CK & C-PK and PCK highly confident. Average for TK, CTCK and CTPK. Lowest was C-TPACK. C-TK, C-TPK and TCK had large positive correlations with C-TPACK (> 0.60). C-TK, C-TPK, and TCK were the key predictors of C-TPACK as these explained 72%	Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK.
Lin et al. (2013)	In-service and pre-service Science teachers (Singapore)	Quantitative 222 primary and secondary school Science teachers in Structural equation models	Seven factors with 27 items on Seven-point Likert scale. Perception of all domains higher. PCK relation to other domains is weaker than others. CK and PK was sig higher for in-service teachers. PK sig higher than males, but TK sig lower than males. Negative correlation between the age of in-service science teachers and the factors of TPACK (TK, TPK, TCK, and TPC). TK significantly and positively correlated with pre-service teachers' age. Gender by age for female in-service was diff for TK, TPK, TCK, and TPC, less confident as the age increase	Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK).

Liu, Zhang, & Wang (2015)	In-service K12 teachers (China)	Quantitative 6,650 in-service K12 teachers in a teacher education program	Five factors with overall high TPACK (above 5 on a 7-point Likert scale) highest perceptions on the PK followed by CK. Lower perception for TK and TPK-TCK-TPACK	Surveying Chinese In-Service K12 Teachers' Technology, Pedagogy, and Content Knowledge.
Long, Zhao, Li, Zhao, Xie, & Duan (2020).	In-service teachers (China)	Quantitative 159 valid responses	Six factors (TK-TT, PK, CK, TPK-TT, PCK, and TPCK-TT). Cronbach's alpha 0.942 and subscales above 0.8 PK was the highest, PCK was lowest, but not sig. TPCK-TT sig. positively correlated with TK-TT, PK, CK, TPK-TT, and PCK. Stepwise regression - TPK-TT, TK-TT, and PK - sig predict TPCK-TT. No sig diff in the components between teachers with two and more years Teaching thinking experience had a significantly higher efficacy of TK-TT, bachelor's degree - sig higher PK than associate degree,	Exploring Chinese in-service primary teachers' Technological Pedagogical Content Knowledge (TPACK) for the use of thinking tools.
Niess (2012)	Pre-service mathematics teachers (USA)	Qualitative	Review of ways pre-service teachers might gather valid and reliable artifacts to be used for judging their knowledge and understandings of the interplay among technology, pedagogy, and content.	Re-Thinking Pre-Service Mathematics Teachers Preparation: Developing Technological, Pedagogical, and Content Knowledge (TPACK)
Owusu Conner & Astall (2015)	High school science teachers (New Zealand)	Mixed-method 102 participants	Identified 7 TPACK constructs High TPACK with mean scores between 3.7 to 4.5 on a 5-point Likert scale with highest score on CK and PK and lower score on TK, TCK, TPK and TPACK	Assessing New Zealand high school science teachers' technological pedagogical content knowledge.
Rahman et al., (2017)	Middle school STEM (Malaysia)	Action research and Survey	Most required TK - ability to program the robots and troubleshoot the program and the robots. PK - ability to differentiate, scaffold, form productive student groups or teams, and CK - grade specific curriculum knowledge was the most required knowledge for teaching both science and math lessons using robotics	Exploring the dynamic nature of TPACK framework in teaching STEM using robotics in middle school classrooms
Redmond & Pele (2019).	Pre-service teachers (Australia & Israel)	Quantitative 209 participants	Seven factors using. Cronbach alpha > 0.7 for all domains. Highest mean for CK and PK, Lowest for TK. Sig diff with high TPACK for those >26 years, sig diff TK and CK - higher in Australian. No significant differences	Exploring TPACK among pre-service teachers in Australia and Israel.

			between genders, no sig diff in TPACK between nations based on age, no sig diff btw subject or nationality by subj	
Sahin (2011)	Preservice English language teachers (Turkey)	Quantitative 348 participants	Developed a survey of TPACK. Seven factors identified after EFA and CFA. Cronbach's alpha > 0.7.	Development of survey of technological pedagogical and content knowledge (TPACK).
Tokmak et al. (2013)	Pre-service mathematics sciences literacy teachers (Turkey)	Quasi-experimental 101 pre-service teachers (31 mathematics, 32 sciences, and 38 literacy) who attended introduction to computers	Significant improvements in all groups of pre-service teachers' mathematics, science, and literacy on their TPACK. No significant differences between natural science (mathematics and science education) and social science (literacy) for pre-service teachers' TPACK. Significant differences between natural science and social science pre-service teachers' technological knowledge and technological content knowledge.	An investigation of change in mathematics, science, and literacy education pre-service teachers' TPACK.
Schmidt, Baran, Thompson, Mishra, Koehler & Shin (2009)	Pre-service teachers (USA)	Quantitative 124 student teachers in an instructional technology course at Midwestern university	Seven factors with factor analysis. 5-point Likert-scale. Cronbach alpha > 0.7 for all seven factors. TPACK was significantly correlated with eight subscales at the .001level	Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers.
Yanış & Yürük (2021)	Pre-service science teachers (Turkey)	Mixed-method exploratory sequential design	Scale was a valid and reliable instrument for measuring pre-service science teachers' ER-TPACK self-efficacy	Development, validity, and reliability of an educational robotics based technological pedagogical content knowledge self-efficacy scale

Appendix C

TPACK Survey

Thank you for taking time to complete this questionnaire. This questionnaire aims to get an understanding of Maldivian teachers' knowledge and use of ICT (e.g., computers, mobile devices, tablet/iPad, interactive whiteboards and software programs) in classroom teaching. The survey contains 30 questions and may take about 15-20 minutes to complete. Please respond to all statements.

PART I - Demographic information

What is your gender?

☐ a. Male ☐ b. Female

What is your age?

____

How long have you been a teacher, including this year?

____

Please select the core subject(s) you teach/taught this past school year (Please check all that apply)

☐ a. Divehi
☐ b. English
☐ c. Mathematics
☐ d. Islam
☐ e. Chemistry
☐ f. Physics
☐ g. Biology
☐ h. Business Studies
☐ i. Accounting
☐ j. Economics
☐ k. History
☐ l. Geography
☐ m. Travel & Tourism Studies
☐ n. Fisheries
☐ o. Computer Studies
☐ p. Art & Design
☐ q. Other subject (please specify below)

____

What grade(s) do you teach? (Please check all that apply)

☐ a. Grade 9 ☐ b. Grade 10

If you are a trained/certified teacher, where did you do your teacher training?

____

Name of the school you work at?

____

PART II - TPACK

Circle the option that best describes you

SD = Strongly Disagree,
D = Disagree,
N = Neither Agree/Disagree,
A = Agree,
SA = Strongly Agree

Technical knowledge						
1	I have the technical skills to use computers effectively	SD	D	N	A	SD
2	I can learn technology easily	SD	D	N	A	SD
3	I know how to solve my own technical problems when using technology	SD	D	N	A	SD
4	I keep up with important new technologies	SD	D	N	A	SD
5	I am able to create web pages	SD	D	N	A	SD
6	I am able to use social media (e.g., Blog, Wiki, Facebook)	SD	D	N	A	SD
Content Knowledge						
7	I have sufficient knowledge about my teaching subject	SD	D	N	A	SD
8	I can think about the content of my teaching subject like a subject matter expert	SD	D	N	A	SD
9	I am able to develop deeper understanding about the content of my teaching subject	SD	D	N	A	SD
Pedagogical Knowledge						
10	I am able to stretch my students' thinking by creating challenging tasks for them	SD	D	N	A	SD
11	I am able to guide my students to adopt appropriate learning strategies	SD	D	N	A	SD
12	I am able to help my students to monitor their own learning	SD	D	N	A	SD
13	I am able to help my students to reflect on their learning strategies	SD	D	N	A	SD
14	I am able to guide my students to discuss effectively during group work	SD	D	N	A	SD
PCK scale score						
15	Without using technology, I can address the common misconceptions my students have for my teaching subject	SD	D	N	A	SD
16	Without using technology, I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject	SD	D	N	A	SD
17	Without using technology, I can help my students to understand the content knowledge of my teaching subject through various ways	SD	D	N	A	SD
TCK scale score						

18	I can use the software that are created specifically for my teaching subject.	SD	D	N	A	SD
19	I know about the technologies that I have to use for the research of content of my teaching subject	SD	D	N	A	SD
20	I can use appropriate technologies (e.g., multimedia resources, simulation) to represent the content of my teaching subject	SD	D	N	A	SD
TPK scale score						
21	I am able to use technology to introduce my students to real world scenarios	SD	D	N	A	SD
22	I am able to facilitate my students to use technology to find more information on their own	SD	D	N	A	SD
23	I am able to facilitate my students to use technology to plan and monitor their own learning	SD	D	N	A	SD
24	I am able to facilitate my students to use technology to construct different forms of knowledge representation	SD	D	N	A	SD
25	I am able to facilitate my students to collaborate with each other using technology	SD	D	N	A	SD
TPACK						
26	I can teach lessons that appropriately combine my subject, technologies and teaching approaches	SD	D	N	A	SD
27	I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn	SD	D	N	A	SD
28	I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom	SD	D	N	A	SD
29	I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school	SD	D	N	A	SD
Familiarity and use of technologies						
30 I am familiar and frequently use following technologies in my teaching:						
	PowerPoint/ Prezi	SD	D	N	A	SD
	Quizzes/ Tests Blogs	SD	D	N	A	SD
	Wikis	SD	D	N	A	SD
	Discussion boards	SD	D	N	A	SD
	Virtual classroom	SD	D	N	A	SD
	Multimedia creation software or web platforms	SD	D	N	A	SD
	Adaptive Learning Platforms	SD	D	N	A	SD
	Cloud-based apps	SD	D	N	A	SD
	Tablet apps	SD	D	N	A	SD
	Web-based social platforms	SD	D	N	A	SD
Please list any other technologies you frequently use in your teaching: ______ ______ ______						

(Adapted from Koh et al. (2013))

PART III –

How would you describe your experience with computers?

- ☐ a. I have never used technology to teach, and I don't plan to do so anytime soon.
- ☐ b. I have never used technology to teach but I would like to learn.
- ☐ c. I rarely use technology for instruction in the classroom (a few times a month, at most)
- ☐ d. I frequently use technology for instruction in the classroom (one or more times a week)
- ☐ e. I always use technology for instruction in the classroom (every day or almost every day)

Can you name some activities you conducted with your students using technology?

____

____

In relation to your answer to the above question:

- What technology did you use to teach?

  ____

  ____

- What did you teach through the activity?

  ____

  ____

- Can you explain how you taught the lesson using the technology?

  ____

  ____

- Can you comment on the effectiveness of the activity?
  - Was it effective? If yes why/why not?

    ____

    ____

  - How was it effective or not effective?

    ____

    ____

  - What did the students think about the activity and what did they learn?

    ____

    ____

  - Did you face any difficulties? If yes, how did you overcome those difficulties, if not, how did you feel about the activity?

    ____

    ____

Any further comments?

____

If you wish to take part in a follow up interview, please provide an email or contact number.

____

End of Survey. Once again, thank you for your time

Appendix D

Summary of survey participants' demographic characteristics

Variable	Categories	Frequency	Percent
Gender	Male	266	54.8
	Female	219	45.2
Age	Below 35 years	208	42.9
	35 to 44 years	163	33.6
	Above 44 years	114	23.5
Teacher training completed	Trained	432	89.0
	Not trained	43	8.9
	Not provided	10	2.1
Years of teaching experience	Less than 5 years	96	19.8
	5 to 10 years	180	37.1
	More than 10 years	209	43.1
Subject taught	Dhivehi	36	7.4
	English	90	18.6
	Mathematics	96	19.8
	Islam	28	5.8
	Chemistry	63	13.0
	Physics	33	6.8
	Biology	63	13.0
	Business Studies	60	12.4
	Accounting	45	9.3
	Economics	50	10.3
	History	10	2.1
	Geography	6	1.2
	Travel & Tourism Studies	18	3.7
	Fisheries Science	18	3.7
	Computer Studies	25	5.2
	Art & Design	9	1.9
	Other	63	13.0
Teaching grade	Grade 9	75	15.5
	Grade 10	63	13.0
	Grades 9 and 10	347	71.5
Nationality	Maldivian	178	36.7
	Indian	301	62.1
	Sri Lankan	6	1.2
Regions	Northern region (*Haa Alif, Haa Dhaalu and Shaviyani, Noonu, Raa, Baa, and Lhaviyani Atolls*)	187	38.6
	The central region (*Malé City, Kaafu, Alif Kaaf, Alif Dhaal, Vaavu, Meemu, Faafu, and Dhaalu Atolls*)	177	36.5
	Southern region (*Thaa and Laamu, Gaafu Alif, Gaafu Dhaalu, Gnaviyani Atoll, and Addu City*)	121	24.9
Atoll vs Capital city	Atoll	424	87.4
	Male' city	61	12.6

Appendix E

Correlation matrix for TPACK scale

	TK1	TK2	TK3	TK4	TK5	TK6	CK1	CK2	CK3	PK1	PK2	PK3	PK4	PK5	PCK2	PCK3	TCK1	TCK2	TCK3	TPK1	TPK2	TPK3	TPK4	TPK5	TPACK1	TPACK2	TPACK3	TPACK4
TK1	1.000	0.606	0.616	0.558	0.362	0.418	0.259	0.264	0.298	0.100	0.150	0.091	0.120	0.151	0.203	0.143	0.394	0.360	0.331	0.442	0.344	0.297	0.209	0.275	0.270	0.234	0.229	0.339
TK2	0.606	1.000	0.486	0.482	0.366	0.459	0.345	0.287	0.400	0.140	0.203	0.073	0.127	0.139	0.205	0.153	0.305	0.333	0.255	0.316	0.288	0.270	0.212	0.206	0.369	0.229	0.252	0.366
TK3	0.616	0.486	1.000	0.485	0.365	0.394	0.218	0.248	0.287	0.122	0.144	0.111	0.049	0.187	0.239	0.144	0.223	0.242	0.339	0.256	0.288	0.173	0.100	0.172	0.178	0.128	0.119	0.286
TK4	0.558	0.482	0.485	1.000	0.357	0.397	0.231	0.286	0.274	0.123	0.216	0.111	0.111	0.195	0.230	0.057	0.300	0.200	0.310	0.337	0.314	0.241	0.202	0.309	0.258	0.313	0.262	0.298
TK5	0.362	0.366	0.365	0.357	1.000	0.301	0.128	0.198	0.223	0.157	0.236	0.169	0.090	0.156	0.044	0.107	0.253	0.220	0.224	0.190	0.198	0.138	0.091	0.149	0.214	0.153	0.145	0.211
TK6	0.418	0.459	0.394	0.397	0.301	1.000	0.228	0.273	0.236	0.171	0.175	0.119	0.107	0.185	0.121	0.067	0.214	0.243	0.409	0.335	0.283	0.183	0.150	0.214	0.163	0.089	0.177	0.153
CK1	0.259	0.345	0.218	0.231	0.128	0.228	1.000	0.584	0.585	0.359	0.376	0.358	0.335	0.407	0.254	0.183	0.154	0.262	0.423	0.315	0.244	0.196	0.160	0.159	0.313	0.339	0.354	0.310
CK2	0.264	0.287	0.248	0.286	0.198	0.273	0.584	1.000	0.652	0.435	0.328	0.343	0.350	0.437	0.216	0.127	0.139	0.282	0.353	0.380	0.380	0.260	0.246	0.173	0.368	0.367	0.383	0.300
CK3	0.298	0.400	0.287	0.274	0.223	0.236	0.585	0.652	1.000	0.510	0.425	0.409	0.437	0.410	0.272	0.240	0.198	0.400	0.464	0.429	0.413	0.317	0.287	0.167	0.361	0.347	0.337	0.284
PK1	0.100	0.140	0.122	0.123	0.157	0.171	0.359	0.435	0.510	1.000	0.670	0.569	0.528	0.479	0.255	0.228	0.160	0.306	0.349	0.232	0.278	0.270	0.227	0.209	0.248	0.347	0.323	0.329
PK2	0.150	0.203	0.144	0.216	0.236	0.175	0.376	0.328	0.425	0.670	1.000	0.646	0.632	0.605	0.233	0.214	0.191	0.283	0.294	0.184	0.184	0.308	0.197	0.286	0.270	0.338	0.375	0.368
PK3	0.091	0.073	0.111	0.111	0.169	0.119	0.358	0.343	0.409	0.569	0.646	1.000	0.709	0.731	0.243	0.211	0.134	0.267	0.287	0.245	0.261	0.327	0.272	0.228	0.269	0.300	0.379	0.296
PK4	0.120	0.127	0.049	0.111	0.090	0.107	0.335	0.350	0.437	0.528	0.632	0.709	1.000	0.681	0.300	0.271	0.250	0.366	0.267	0.217	0.293	0.417	0.358	0.386	0.353	0.452	0.453	0.362
PK5	0.151	0.139	0.187	0.195	0.156	0.185	0.407	0.437	0.410	0.479	0.605	0.731	0.681	1.000	0.278	0.185	0.145	0.322	0.305	0.273	0.288	0.306	0.276	0.342	0.341	0.287	0.408	0.321
PCK2	0.203	0.205	0.239	0.230	0.044	0.121	0.254	0.216	0.272	0.255	0.233	0.243	0.300	0.278	1.000	0.606	0.178	0.229	0.256	0.168	0.179	0.304	0.261	0.298	0.294	0.270	0.220	0.278
PCK3	0.143	0.153	0.144	0.057	0.107	0.067	0.183	0.127	0.240	0.228	0.214	0.211	0.271	0.185	0.606	1.000	0.238	0.178	0.248	0.119	0.089	0.312	0.261	0.235	0.213	0.187	0.148	0.269
TCK1	0.394	0.305	0.223	0.300	0.253	0.214	0.154	0.139	0.198	0.160	0.191	0.134	0.250	0.145	0.178	0.238	1.000	0.435	0.336	0.295	0.364	0.346	0.372	0.365	0.349	0.326	0.259	0.276
TCK2	0.360	0.333	0.242	0.200	0.220	0.243	0.262	0.282	0.400	0.306	0.283	0.267	0.366	0.322	0.229	0.178	0.435	1.000	0.473	0.413	0.354	0.341	0.352	0.244	0.379	0.363	0.494	0.265
TCK3	0.331	0.255	0.339	0.310	0.224	0.409	0.423	0.353	0.464	0.349	0.294	0.287	0.267	0.305	0.256	0.248	0.336	0.473	1.000	0.512	0.400	0.239	0.282	0.248	0.397	0.408	0.353	0.360
TPK1	0.442	0.316	0.256	0.337	0.190	0.335	0.315	0.380	0.429	0.232	0.184	0.245	0.217	0.273	0.168	0.119	0.295	0.413	0.512	1.000	0.448	0.290	0.393	0.217	0.376	0.396	0.411	0.191
TPK2	0.344	0.288	0.288	0.314	0.198	0.283	0.244	0.380	0.413	0.278	0.184	0.261	0.293	0.288	0.179	0.089	0.364	0.354	0.400	0.448	1.000	0.507	0.486	0.412	0.348	0.396	0.371	0.203
TPK3	0.297	0.270	0.173	0.241	0.138	0.183	0.196	0.260	0.317	0.270	0.308	0.327	0.417	0.306	0.304	0.312	0.346	0.341	0.239	0.290	0.507	1.000	0.725	0.637	0.314	0.361	0.344	0.314
TPK4	0.209	0.212	0.100	0.202	0.091	0.150	0.160	0.246	0.287	0.227	0.197	0.272	0.358	0.276	0.261	0.261	0.372	0.352	0.282	0.393	0.486	0.725	1.000	0.635	0.430	0.441	0.314	0.241
TPK5	0.275	0.206	0.172	0.309	0.149	0.214	0.159	0.173	0.167	0.209	0.286	0.228	0.386	0.342	0.298	0.235	0.365	0.244	0.248	0.217	0.412	0.637	0.635	1.000	0.362	0.390	0.287	0.339
TPACK1	0.270	0.369	0.178	0.258	0.214	0.163	0.313	0.368	0.361	0.248	0.270	0.269	0.353	0.341	0.294	0.213	0.349	0.379	0.397	0.376	0.348	0.314	0.430	0.362	1.000	0.564	0.463	0.400
TPACK2	0.234	0.229	0.128	0.313	0.153	0.089	0.339	0.367	0.347	0.347	0.338	0.300	0.452	0.287	0.270	0.187	0.326	0.363	0.408	0.396	0.396	0.361	0.441	0.390	0.564	1.000	0.605	0.487
TPACK3	0.229	0.252	0.119	0.262	0.145	0.177	0.354	0.383	0.337	0.323	0.375	0.379	0.453	0.408	0.220	0.148	0.259	0.494	0.353	0.411	0.371	0.344	0.314	0.287	0.463	0.605	1.000	0.414
TPACK4	0.339	0.366	0.286	0.298	0.211	0.153	0.310	0.300	0.284	0.329	0.368	0.296	0.362	0.321	0.278	0.269	0.276	0.265	0.360	0.191	0.203	0.314	0.241	0.339	0.400	0.487	0.414	1.000

Appendix F

Total Variance Explained for the TPACK Scale

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.851	32.780	32.780	8.851	32.780	32.780
2	2.742	10.154	42.934	2.742	10.154	42.934
3	2.006	7.431	50.364	2.006	7.431	50.364
4	1.381	5.116	55.480	1.381	5.116	55.480
5	1.278	4.734	60.214	1.278	4.734	60.214
6	1.134	4.199	64.413	1.134	4.199	64.413
7	.974	3.608	68.021	.974	3.608	68.021
8	.779	2.886	70.907			
9	.730	2.705	73.613			
10	.678	2.513	76.125			
11	.668	2.475	78.600			
12	.616	2.282	80.882			
13	.590	2.186	83.068			
14	.539	1.997	85.065			
15	.492	1.822	86.888			
16	.443	1.639	88.527			
17	.398	1.475	90.002			
18	.384	1.422	91.424			
19	.351	1.298	92.723			
20	.325	1.204	93.926			
21	.317	1.175	95.101			
22	.270	.999	96.100			
23	.248	.918	97.017			
24	.225	.832	97.849			
25	.206	.764	98.613			
26	.188	.696	99.308			
27	.187	.692	100.000			

Extraction Method: Principal Component Analysis.

Appendix G

Output from Parallel Analysis for the TPACK scale

Specifications for this Run:
Ncases 485
Nvars 27
Ndatsets 500
Percent 95

Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues

Root	Mean	Percentile	Raw Data
1.00000	1.458294	1.523782	8.850513
2.00000	1.388790	1.433061	2.741554
3.00000	1.340522	1.381536	2.006305
4.00000	1.296410	1.339888	1.381264
5.00000	1.254116	1.289961	1.278262
6.00000	1.221205	1.249483	1.133636
7.00000	1.188358	1.216328	0.974193
8.00000	1.157679	1.182903	0.779263
9.00000	1.126678	1.151420	0.730392
10.00000	1.094506	1.116990	0.678415
11.00000	1.066961	1.092360	0.668303
12.00000	1.039439	1.064734	0.616058
13.00000	1.012689	1.038829	0.590227
14.00000	0.985778	1.004205	0.539283
15.00000	0.960519	0.986755	0.492072
16.00000	0.932837	0.955263	0.442586
17.00000	0.905015	0.928411	0.398334
18.00000	0.88071	0.903476	0.383914
19.00000	0.853559	0.880529	0.350559
20.00000	0.827713	0.854066	0.325000
21.00000	0.802193	0.831234	0.317200
22.00000	0.773914	0.799287	0.269631
23.00000	0.748455	0.773828	0.247734
24.00000	0.720217	0.743135	0.224510
25.00000	0.691281	0.720511	0.206217
26.00000	0.656173	0.685562	0.187808
27.00000	0.61599	0.646545	0.186766

Principal Components & Random Normal Data Generation

Appendix H

Model fit indices

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	75	424.317	303	.000	1.400
Saturated model	378	.000	0		
Independence model	27	2470.806	351	.000	7.039

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.828	.801	.944	.934	.943
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.048	.037	.059	.605
Independence model	.187	.180	.194	.000

Appendix I

Residuals statistics - Mahalanobis distance score

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.3710	3.8241	3.1918	.21994	485
Std. Predicted Value	-3.732	2.875	.000	1.000	485
Standard Error of Predicted Value	.053	.333	.110	.034	485
Adjusted Predicted Value	2.2954	3.8001	3.1924	.22053	485
Residual	-1.75861	2.01942	.00000	.89044	485
Std. Residual	-1.961	2.251	.000	.993	485
Stud. Residual	-1.984	2.270	.000	1.001	485
Deleted Residual	-1.80010	2.05227	-.00065	.90530	485
Stud. Deleted Residual	-1.990	2.280	.000	1.002	485
Mahal. Distance	.713	65.567	6.986	5.796	485
Cook's Distance	.000	.035	.002	.003	485
Cantered Leverage Value	.001	.135	.014	.012	485

Appendix J

Description of participants in the qualitative phase

Name	Gender	Age	Qualification	Region	Subject taught	Grade taught	Teacher training	Teaching experience	Experience teaching with technology	Technology training	Overall TPACK (27 items)	TPACK level
Ameen	Male	51	Diploma	North	Islam	10	Yes	>27	4	Yes	4.33	Very high
Lirgam	Male	35	Masters degree	North	English	10	Yes	8	4	Yes	3.93	High
Malik	Male	28	Bachelors degree	North	Mathematics	9	No	6	3	Yes	4.19	High
Anil	Male	36	Postgraduate	Central	Physics	9,10	Yes	9	5	Yes	4.11	High
Suma	Female	44	Masters degree	Central	Business Studies	9,10	Yes	16	4	Yes	4.33	Very high
Fariyal	Female	50	Masters degree	Central	English	9, 10	Yes	24	4	Yes	3.89	High
Aanisa	Female	32	Bachelors degree	South	Economics	9,10	Yes	9	4	Yes	4.37	Very high

Raihana	Female	36	Bachelors degree	South	Mathematics	9	Yes	9	4	Yes	3.7	High
Shidhatha	Female	40	Masters degree	South	Chemistry	9	Yes	> 15	4	Yes	3.59	High

Appendix K

Semi-structured interview questions

1) What type of technologies (hardware and software) are available for use in assisting student learning?
2) Which of the technologies (mentioned by participant in q1) do you use to support student learning?
3) How do you and students use the available technologies to support student learning? Can you give few examples?
4) How did you learn to integrate technology in your teaching?
5) How do you continue to acquire knowledge of technology device use?
6) How do you determine what technology to use with your students?
7) What are some instructional strategies that technology can help in differentiating instruction for diverse students?
8) Are there any frameworks you apply to integrate technology in your lessons? Please elaborate
9) Do you use Blooms Taxonomy in your planning of lesson activities, if yes how?
10) Are you aware of Blooms digital taxonomy (BDT)? If yes, do you use BDT in planning lesson activities that use technology?
11) Are you aware of the Substitution, Augmentation, Modification and Redefinition (SAMR) model? If yes, can you explain how you apply the model in your instructional practice?
12) What factors do you believe enable you to adopt technology in your classrooms?
13) What factors do you believe hinder you from adopting technology in your classrooms?
14) How does the school management (principal, deputy principal, leading teachers) support you to use technology devices and applications in your classroom?
15) How does the school management make technology accessible for you to use them in your classroom?
16) In what ways are you provided with the informational resources regarding integrating technology in the curriculum?
17) What kind of training have you gone through to be able to integrate the technology in your classroom? Can you elaborate?

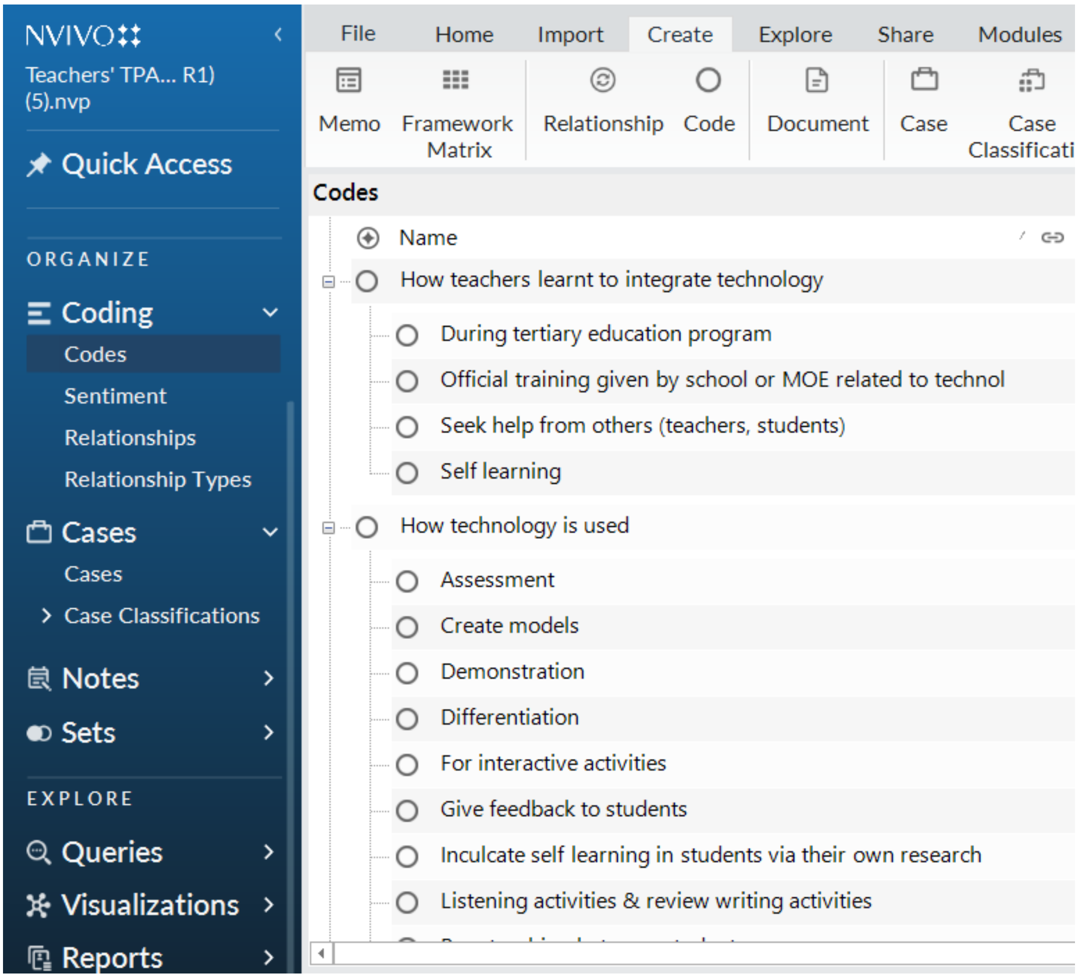
18) Did these trainings help with technology integration in the classroom? If yes, how? If no, why do you say so? Can you elaborate?

19) Is there anything else you would you like to share?

Would it be possible to share some instances (document or picture) of technologies used in your lessons? (e.g., lesson plan, syllabus/ schemes, assessment criteria, work produced by students such as assessment/ activity tasks).

Appendix L

Initial coding in NVivo – Sample



Appendix M

Sample theme generation - How teachers integrated technology in their lesson

Initial Code	Axial code	Coded excerpt/s	Theme	Description	Interview	RQ
Online quiz… Online filling the blanks	Conduct online quiz	<u>Excerpt 5</u> *For example, we can do quiz…like filling the blanks and all, so that they will learn the concept but in a simpler way. For example, for fill in the blanks also, in the virtual system we do it…when they click on the blank, there will be three options…and from that option, they get to choose, which is the word which is most suitable for that. Like that, if such activities are given, it will be easy for the slow learners.*	Conduct assessment activities using interactive or online MCQ quizzes	Conduct assessment activities using interactive or online MCQ quizzes. These activities fall under the augmentation level based on the SAMR framework since it allows students to practice repeatedly and verify answers.	Interview - ANFEYS	RQ2
Practice for exams using online quiz	Practice using online quiz	<u>Excerpt 5</u> *if they are logged into my subject means they can get to access whatever information that is available, whatever I am providing. So, like it is easier…for example, if a kid is not present to the school also, the kids can actually access to information, like whatever the notes, whatever the things I'm doing in the class from that. Even if they lose their notes and anything…like they want to practice for their exams, so those quizzes they can do, like practice which is needed. So, it is easier, even without the contact between the teacher and the student*			Interview - ANFEYS	RQ2
Assessing and all (use tablets) Do the quizzes on their tablets	Conduct online assessment	<u>Excerpt 7</u> *For assessing and all (use tablets)* *For assessment purpose (tablets)* *tablet it will only be for assessing and all*			Interview – ANFEYS Interview – ANFEYS Interview – ANFEYS	RQ2
Do the quizzes on their tablets	Augmentation	<u>Excerpt 8</u> *I also prepare different kinds of quizzes for students to do.* *I also prepare quizzes and students also prepare quizzes.*			Interview - AHFUS	

Appendix N

Theme generation - Factors affecting teachers' technology integration (Sample 1 - Training)

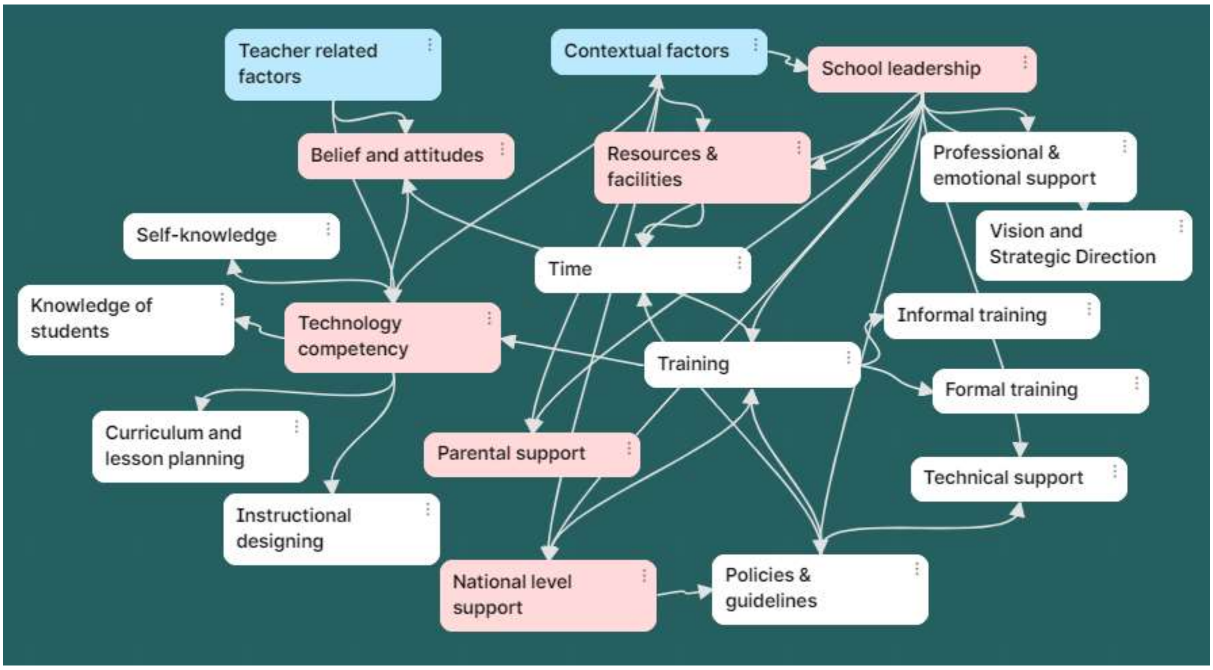
Initial Code	Axial code	Coded excerpt/s	Theme	Description	Interview	RQ
exploring on my own learning how others are doing always practice always keep note	Self- exploring	*I never went for any type of computer course or anything. Just by exploring and learning how others are doing and all. By exploring on my own I learned.* *Through learning and all. I always practice. For example, if I forget something, I always keep note of how to do it and all and through that I learn…and if there is a new thing and all I learn from those who know it…and through internet.*	Self-learning	Learn by own exploration; either by reading (e.g., education magazines daily newspapers); Googling, or asking from friends	Interview - ANFEYS	RQ3
usually google it or YouTube	Googling	*Whenever I used to be in doubt, I usually google it or YouTube…otherwise we share with other friends.*			Interview - LFUS	RQ3
information from YouTube From website	From YouTube	*By using information from YouTube…we used to learn from it.* *I used to collect some information from website. So, in that case, the way is to make it easy for students. So, I used to go for that. in that case, like GeoGebra, algorithm package, interactive math, those things I use … Another website (Interactive math)* *I'm just using what they are giving…I'm getting information from website… My own inquiry*			Interview - MFUS	RQ3
seek information a lot	Self-seeking	*I do seek information a lot. I ask from friends how they prepare lessons; I check how they have prepared, what they have done. Also, the staff here are quite skillful in technology…the computing teachers here are also very good, though they may not be able to explain those things. So, to get information for further development, we don't have anyone we can go to. But if opportunity arises, I will make use of it. Also, if there is anyone who is knowledgeable, I will contact and learn from them. Cos, now that I have experienced, I know how interesting and easy it is.*			Interview - AHFUS	RQ3
self-experience and also through self-reading	Self-reading	*Yes…and also, I have developed through my private, my own experience, self-experience and also through self-reading right through internet and all.* *I read the education magazines and sometimes from daily newspapers, there are certain pages for educational right*			Interview - ASDS	RQ3

Theme generation - Factors affecting teachers' technology integration (Sample 2 – Teacher beliefs)

Initial Code	Axial code	Coded excerpt/s	Theme	Description	Interview	RQ
Over excitement of students	Over excitement of students	<u>Excerpt 1</u> IW- "*Like if you ask students to take the tablet to their classroom, sometimes they are overexcited…if they have the tablet. So, sometimes it's getting difficult.*"	Teachers' beliefs about using technology - Students get distracted	Sometimes teachers find it difficult when students are over excited and get distracted when using technologies. For some students, once they become familiar with tablets, they get bored and become less interested in learning using the tablet.	Interview – SFEYS	RQ3
There was chaos in the class…like, they were playing games, so many new things they wanted to try Students were so excited that they wanted to enjoy some other thing (with tablets). Students were distracted students may not have the tablets forget to bring	Students were distracted	<u>Excerpt 2</u> IW- "*I tried once and that day there was chaos in the class…like, they were playing games, so many new things they wanted to try. So, the things…the quiz I wanted I was not able to conduct.*" <u>Excerpt 3</u> IW- "*Students were so excited that they wanted to enjoy some other thing (with tablets). They wanted to share so many other things*" <u>Excerpt 4</u> IW- *"Yea students were distracted"* *Then some technical issues like, some may have tablets, some students may not have the tablets.* *They (students) have (tablet), but they may forget to bring because every day we don't have. We ask them to bring it*			Interview – RFEYS Interview - RFEYS Interview – RFEYS	RQ3
Students are misusing it When students are given work, they are doing something else	Students are misusing it	<u>Excerpt 5</u> IW- "*And some students are misusing it. "Of course, we are responsible in the classroom. Whatever they are using. In some classes, there are many obstreperous Students. It's difficult to control them*" <u>Excerpt 6</u> IW- *"When they (students) are given work, they are doing something else"*			Interview - LFUS Interview – LFUS	RQ3

Appendix O

Conceptualization of factors affecting teachers’ technology integration



Appendix P

Final conceptualization of factors affecting teachers' technology integration into different contextual levels

Factors	Sub-category	Participant	Contextual level
Teacher-related factors	**Factors related to resources and facilities**		**Micro level**
	Belief and attitudes *Positive belief (9)* *Negative beliefs (5)*	Fariyal, Anil, Shidhatha, Aanisa, Lirgam, Ameen, Raihana, Malik, Suma	
	Knowledge and competencies *Self-knowledge (5)* *Knowledge of students (4)* *Curriculum and lesson planning (6)* *Instructional design principles (9)*	Fariyal, Anil, Shidhatha, Aanisa, Lirgam, Ameen, Raihana, Malik, Suma	
	Access to software/ hardware resources, & facilities, (17)	Fariyal, Anil, Shidhatha, Aanisa, Lirgam, Ameen, Raihana, Malik, Suma	
	Technology devices damaged (8)	Aanisa, Lirgam, Ameen	
	Connectivity and Wi-Fi issues (15)	Anil, Suma, Shidhatha, Aanisa, Raihana, Lirgam	
	Time (5)	Anil, Raihana	
Contextual factors	**Factors related to school leadership, culture, and community**		**Meso level**
	School leadership & management support (15) *Resources and facilities (9)* *Professional and emotional (9)*	Anil, Suma, Fariyal, Aanisa, Shidhatha, Raihana, Ameen, Malik, Lirgam	
	Technical support, help & assistance (19) *Technical problems (9) &* *Teachers' technical know-how (7)*	Anil, Suma, Fariyal, Aanisa, Raihana, Lirgam	
	Support with training (14) *Formal training (workshops from school, MoE, and teacher training)* *Informal training (self-learning, Googling, YouTube, reading)* *Learning from colleagues* *Learning from students*	Anil, Suma, Fariyal, Aanisa, Shidhatha, Raihana, Ameen, Malik, Lirgam	
	Factors related to parental community		**Exo level**
	Parent funding and support (5) Unwillingness of parents (4)	Suma, Shidhatha, Raihana, Lirgam, Malik, Ameen, Aanisa	
	Factors related to support at national level		**Macro level**
	Government (MoE) funding and Implementation (6) Professional development training and support (9)	Anil, Lirgam, Aanisa, Ameen, Fariyal, Raihana	

Appendix Q

SAMR assessment tool

SAMR level	Description	Example activities
Enhancement	**Substitution** Technology acts as a direct tool substitute with no functional change.	• Use a word processing program to type out a story or essay instead of handwriting • Accessing and reading digital texts (e.g., PDFs, digital textbooks) • Use an online dictionary for key terms • Sharing content online • Technology based drill and practice activities (e.g., memorizing vocabulary using digital flashcards) • Accessing and responding to digital content (e.g., email responses), commenting on a twitter post • Use a drawing app such as doodle to solve a math problem • Learning multiplication tables and spelling using digital tools • Tracing letters on a digital device (e.g., Tablet, IWD)
	Augmentation Technology acts as a direct tool substitute with functional improvement.	• Use functions to make sure words are spelled correctly, check grammar (e.g.: Spell Check, Thesaurus in MS Word, Word Count, etc.) • Use hyperlink on a word document or presentation to link to additional resources • Viewing a video that pauses automatically to ask questions, which allows to input answers and give scores to the responses • Posting to a class blog or website • Creating infographics, mind maps (e.g., on padlet, MS PowerPoint) • Viewing artefacts, documents virtually
Transformation	**Modification** Technology allows for significant task redesign.	• Uses a screen casting website or App to illustrate and verbally explain how they solved the problem. • Bring a story to life using an online multimedia application (Flipboard, Sock Puppets, etc) • Creating a graphic organizer that includes hyperlinks, images or videos • Searching massive databases from a range of sources (text, image, video, etc.) for information

		• Visiting places that no longer exists or doing virtual tours and experiments. E.g., Ancient Rome, Space, dissecting and examining human body parts virtually • Collaborating on a document in real time digitally (e.g., on Google docs)
	Redefinition Technology allows for the creation of new tasks previously inconceivable.	• Creates videos or multimedia presentations on various topics or problems and posts to a blog, website or App for other students to solve. Student provides feedback for those solving their problems. • Use video conferencing to tell a story (Google Hangout, Poly Com, Fact Time, etc.) • Participate in game-based learning using websites and digital tools • Developing an online blog for others to read • Recording and editing music

Sources: Puentedura (2012) (2014b) (2014a); (Blundell, 2017); Thornton (2017); Cherner and Curry (2017)

Appendix R

Bloom's Digital Taxonomy assessment tool

Bloom's cognitive thinking level	Digital activity
Remembering	
Recalling specific information (Recall or recognition of specific information). Recognising, Listing, Describing, Identifying, Retrieving, Naming, Locating/Finding, Bullet pointing, highlighting, bookmarking, social networking, social bookmarking, favouriting/local bookmarking, Searching, googling, Quiz	**Quiz/Test** (Online tools, WP, Cue sheets) **Flashcards** (Moodle, Hot potatoes, scorm objects) **Definition** (WP – bullets and lists, simple Mind maps, wiki, Moodle Glossary) **Fact** (WP – bullets and lists, Mind maps, internet, discussion boards, email) **Worksheet/book** (WP, Mind map, Web, clozed activities) **Label** (WP, graphics tools) **List** (WP – bullets and lists, Mind map, Web publishing – personal web page, blog journal) **Reproduction** (WP – note writing & dictation, web publishing personal web page, blog journal, graphics tools, Chatrooms, email, discussion boards) **Bookmarking** internet browsers, web 2.0 tools del.icio.us **Social Networking** - Facebook, myspaces, bebo **Basic Searches** - search engines google
Understanding	
Explaining/defining ideas or concepts (Understanding of given information). Interpreting, Exemplifying, Summarising, Inferring, Paraphrasing, Classifying, Comparing, Explaining, Advanced searches, boolean searches, blog journaling, twittering, categorising and tagging, commenting,	**Recitation** (WP, Mind map, flashcards, presentation tools) **Summary** (WP, Mind map, web publishing – blog journals & simple page construction collaborative documents, wiki) **Collection** (WP, Mind map, web publishing – blog journals & simple page construction collaborative documents, wiki) **Explanation** (WP, Mind map, web publishing – blog journals & simple page construction collaborative documents, wiki) **Show and tell** (WP, presentation – online & desktop based, graphics, audio tools - audacity sound recorder & podcasting tools, video tools, Mind map) **List** (WP, Mind map) **Label** (WP, Mind map, Graphics, online tools - Ajaxdraw)

	Outline (WP, Mind map) **Advanced and Boolean searches** - advanced search features - google etc **Blog journaling** - Bloglines, blogger etc **Diary/Journal** (blogging, Myspaces, Bebo, Facebook, Bloglines, blogger) **Categorising and tagging** - Del.icio.us etc **Tagging, comments annotating** - -noticeboards, discussion boards, threaded discussions, adobe acrobat reader, blog readers, Firefox, Zotero **Subscribing** - aggregators - Bloglines, Firefox extensions
Applying	
Using information, concepts and ideas in another familiar situation (Using strategies, concepts, principles and theories in new situations). Implementing, carrying out, using, executing, doing, running, loading, playing, operating, hacking, uploading, sharing, editing	**Illustration** (Corel, Inkscape, GIMP, Paint, online tools, Comic creation tools – comic life, historic tale construction kit, hyper comic) **Simulation** (Floor map, graphic tools, google SketchUp, Crocodile software simulating science experiments, Global conflict - Palestine) **Sculpture or Demonstration** (Presentation, graphics, screen capture, audio and video conferencing) **Presentation** - impress, PowerPoint, google presentation, Zoho presentation, skype, interactive whiteboard collaboration using etools, audio and video conferencing **Interview** (WP, mind mapper, podcast, vodcast, audacity, sound recorder, collaboration using etools, skype) **Performance** (Podcast, vodcast, film, audio and video conferencing, VoIP, audio recording, speech, PowerPoint Show, collaboration using etools) **Editing** - video and sound tools **Playing** - mmorpg's online games, simulations like Global Conflicts Palestine
Analysing	
Breaking information into parts/components to explore/develop/construct understandings and relationships (Breaking information down into its component elements). Comparing, organising, deconstructing, attributing, outlining, structuring, integrating, mashing, linking, reverse engineering, cracking, mind-mapping.	**Survey** (Web based tools – survey monkey, embedded polls and votes, social networking tools etc, WP, Spreadsheet, email, discussion boards, cellphones and texting) **Database** (relational; databases using MySQL and Access, Flatfile database using Spreadsheet, wikis, Geographical information systems or GIS - Google earth, Google Maps, Flickr, Arcview/explorer) **Abstract** (WP, web publishing) **Relationship mind maps** - Herring or fish bone mind maps, SWOT Analysis, PMI, Venn, 6 Questions - Inspiration, kidspiration, smart ideas, Cmap, Mindmapper, freemind Online tools - **Report** (WP, DTP, spreadsheet, presentation, web publishing – web page or blog entry, Graph (Spreadsheet, digitizer, online graphing tools) **Spreadsheet** (Calc, excel, online spreadsheet tools) **Checklist** (WP, survey tools, online polls, Spreadsheet)

	Chart (Spreadsheet, digitizer, mind mapping tools online tools - www.gliffy.com)
Evaluating	
Justifying a decision, solution, answer or course of action (Judge/evaluate/analyse the value of ideas, concepts, materials and methods by developing/constructing and applying standards and criteria). Checking, Hypothesising, Critiquing, Experimenting, Judging, Testing, Detecting, Monitoring (Blog/vlog), commenting, reviewing, posting, moderating, collaborating, networking, reflecting, (Alpha & beta) testing.	**Debate** (WP, sound recorder, podcasting or vodcasting, Mind mapping - inspiration, free mind, Chatrooms, IM, email, Discussion boards, video and Phone conferencing [skype, IM] Collaboration tools – elluminate etc) **Panel** (WP, chatrooms, IM, email, Discussion boards, Video and phone conferencing, Collaboration tools - elluminate etc)) **Report** (WP or web published – Report, blog entry, wiki entry, web page, DTP, Presentation, Camera) **Evaluation** (WP or web published –report blog entry, wiki entry, web page, DTP, Mind Map Presentation, camera) **Investigation** (Internet, Online tools, camera, WP, GIS [Google earth, Google Maps, Flickr Arcview/explorer]) **Verdict** (WP etc) **Conclusion** (WP, DTP, Presentation) **Persuasive speech** (WP, Sound recorder, reason!able -argument software, Mind map - presentation mode) **Commenting, moderating reviewing posting** - discussion boards, forums, blog, wiki's, twitter, threaded discussions, bulletin boards, chatrooms **Collaborating**: discussion boards, forums, blog, wiki's, twitter, threaded discussions, bulletin boards, chatrooms, video conferencing, chatrooms, instant messaging, txt and pxt messaging, video messaging audio conferencing **Networking** - social networking tools, audio and video conferencing, email threads, telecommunications, instant messaging, live classrooms - elluminate etc
Creating	
Generating/creating new ideas, products, or ways of viewing things (Putting together/combining ideas, concepts or elements to develop/construct/build an original idea or engage/stimulate in creative thinking). Designing, Constructing, Planning, Producing, Inventing, Devising, Making, Building, Programming, Filming, Animating, Blogging, Video Blogging, Mixing, Remixing, Wiki-ing, Publishing, Videocasting, Podcasting, Directing/producing.	**Film** (Movie maker, Pinnacle Studio, Adobe premier elements Online tools www.jumpcut.com, www.eyespot.com, www.pinnacleshare.com, www.cuts.com, www,animoto.com, www.dvolver.com) **Presentation** (presentation tools - PowerPoint, Impress, Zoho presentation tool, Photostory, Google present. Comic creation tools – comic life, hypercomic, online tools) **Story** (WP or web published – mixbooks etc, DTP, Presentation, podcasting, photostory, voicethread, Comic creation tools – comic life, historic tale construction kit, Animations – www.dvolver.com) **Programming** Visual Studio.net (& Express the free version) Lego Mindstorms & Robolab, Scratch, Alice, Game maker **Project** (WP, Ganttproject for Gantt charts and PERT Charts, Openproj for gantt, Pert and critical pathways) calendars, flow charts [inspiration, freemind, C-Map, smartideas], mind maps) **Blogging video blogging** - Blogging tool, blogger, wordpress, edublogs, classroom blogmiester, bloglines **Vodcast, podcast videocasting screen casting** - voice thread, blogging tool, skype, collaboration and classroom tools – elluminate, live classroom

	Plan (Inspiration, Cmap, free mind, WP, Calendar) **New game** (Gamemaker, RPGmaker) **Model** (Sketchup, Blender, Maya3d PLE, autocad) **Song** (finale notepad, WP, Sound recorder, Audacity, podcasting, recording narration in presentations [photostory 3, PowerPoint, impress] Online tools **Media product** (DTP, Movie maker, Corel, GIMP, Paint.net, Tuxpaint, Alice, Flash, Podcasting - **Advertisement** (DTP, Corel, GIMP, Paint.net, Tuxpaint, Movie maker, Alice, Flash, Podcasting) **Painting** (Corel, Paint, GIMP, Paint.net, Tuxpaint online tools - http://www.picnik.com http://www.ajaxwrite.com/)

Source: Churches (2008)

a

Appendix S

Information Sheet

You are invited to be in a research study about teachers' knowledge and integration of technology in teaching and learning. You are selected as a possible participant because of your school principal's willingness to support the study. This survey has 30 questions and can be completed in no more than 30 minutes. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This research is being conducted by Aminath Waseela, a doctoral student at Queensland University Technology (QUT), Australia, under the supervision of Dr. Vinesh Chandra and Dr. Shaun Nykvist. The objective of this study is to examine teachers' TPACK knowledge and how the knowledge is applied in classroom teaching for enhanced student engagement and learning. Data will be collected across all government schools in the Maldives. The survey is sent via email (and if required, as hard copies) to all teachers of government schools in Male' and the atoll schools.

Benefits: The information collected will not benefit you directly, but the findings from this study can provide general benefits to teacher trainers, administrators, and researchers interested in integrating technology in their classroom teaching.

Participation: Participation in this research study is completely voluntary. You have the right to withdraw at any time or refuse to participate entirely. You can withdraw your consent and discontinue participation at any time. Nothing you say on the survey questionnaire will in any way influence your present or future employment with your school. There is no compensation from the researchers for participation. Your participation would be a voluntary service from you.

Confidentiality: All data obtained from participants will be kept confidential. Only the researchers will see any personal identification information. Any report of the research will be presented as aggregated responses (i.e., combined results) and never individual responses. No one will know whether you participated in this study. Nothing you say on the questionnaire should in any way influence your present or future employment with your school. The data collected will be stored in a secure database located in the researchers' university until it has been deleted by the primary investigator.

Risks/Discomforts: There are no anticipated risks or discomforts to participants of this study.

Questions about the Research: If you have any questions about this project, you may contact me, Aminath Waseela at a.waseela@hdr.qut.edu.au or my advisors, Dr. Vinesh Chandra (v.chandra@qut.edu.au) and Dr. Shaun Nykvist (s.nykvist@qut.edu.au). If you would like to talk to someone other than the researcher(s), you are encouraged to contact QUTs Office of Research Ethics and Integrity at +61 7 3138 3174 or orei.enquiries@qut.edu.au. All reports or correspondence will be kept confidential.

Continue to next page if you agree to participate in this study.

Appendix T

TPACK Survey Flyer

QUEENSLAND UNIVERSITY OF TECHNOLOGY
FACULTY OF EDUCATION
OFFICE OF EDUCATION RESEARCH
149 Victoria Park Rd, Kelvin Grove QLD 4059 Brisbane, Australia
Phone: +61 7 3138 2000

Teachers' TPACK and technology integration

Participants are needed for a research on TPACK (Technological and Pedagogical Content Knowledge) and technology integration in teaching.

WHAT IS THE RESEARCH ABOUT?

With integration of ICT in schools on the rise, teachers are required to be well versed with the types of technologies and how these can be used to benefit student learning. Therefore, if a teacher has to adopt education technology such as laptops, tablets in their classroom teaching, why not find out your own TPACK and how this knowledge can be utilized to integrate technology and engage students in your classroom?

WHAT IS TPACK?

The TPACK (Mishra & Koehler, 2006) is a model that emphases three types of knowledge (Knowledge of Content, Pedagogy & Technology) that teachers require to teach effectively using ICT.

WHAT IS INVOLVED?

You will be asked to participate in a 20 to 30 minutes, online survey about TPACK
Volunteering teachers will be invited for a face to face interview with the researcher and
Share document artefacts (eg: lesson plan, students' work)

WHEN IS THIS HAPPENING?

Survey will be conducted at the beginning of second term 2019 (June/July)
Semi-structured interviews will be carried throughout the term (August to November 2019)

WHO IS ELIGIBLE?

Teachers teaching in grades 9 and 10 of government schools in the Maldives.

WHO IS UNDERTAKING THE RESEARCH?

Ms Aminath Waseela, Queensland University of Technology (QUT) PhD candidate
Email: a.waseela@qut.edu.au Mobile: +96 0999 2304; +614 2155 5778
For more information, questions or queries about the research, please contact the researcher

This study has received ethics clearance by the QUT Human Research Ethics Committee (approval number 1900000274).

Appendix U

Ethics approval from QUT

QUT

University Human Research Ethics Committee (UHREC)

HUMAN RESEARCH ETHICS APPROVAL CERTIFICATE

NHMRC Registered Committee Number EC00171

Date of Issue: 17/6/19 (supersedes all previously issued certificates)

Dear Dr Vinesh Chandra

This approval certificate serves as your written notice that the proposal has met the requirements of the *National Statement on Ethical Conduct in Human Research* and has been approved on that basis. You are therefore authorised to commence activities as outlined in your application, subject to any specific and standard conditions detailed in this document.

Project Details

Category of Approval: Negligible-Low Risk

Approved From: 31/05/2019 **Approved Until:** 31/05/2024 (subject to annual reports)

Approval Number: 1900000274

Project Title: Teachers' TPACK knowledge and technology integration in teaching and learning: A case study in Maldives

Investigator Details

Chief Investigator: Dr Vinesh Chandra

Other Staff/Students:

Investigator Name	Type	Role
Dr Shaun Nykvist	Internal	QUT Associate Supervisor
Ms Aminath Waseela	Student	Doctoral (Research)

Conditions of Approval

Specific Conditions of Approval:

No special conditions placed on approval by the UHREC. Standard conditions apply.

Standard Conditions of Approval:

1. Conduct the project in accordance with the principles of the NHMRC National Statement on Ethical Conduct in Human Research 2007, the Australian Code for the Responsible Conduct of Research, any additional specific conditions defined by the UHREC, any associated NHMRC guidelines and regulations, and the provisions of any legislation which is relevant to the project;
2. Obtain UHREC approval for any proposed variation to the project **prior** to implementation (note that major changes may require a different level of review and/or submission of a new application);
3. Obtain any additional approvals or authorisations as required (e.g. from other ethics committees, collaborating institutions, supporting organisations);
4. Maintain research records and data in accordance with MoPP D/2.8 Management of research data.
5. Respond promptly to the requests and instructions of UHREC;
6. Declare all actual, perceived or potential conflicts of interest (NS 5.4);
7. Immediately advise the Office of Research Ethics and Integrity (OREI) of any concerns, complaints or adverse events including (NS 5.5.3):
   - if any unforeseen development or events occur that might affect the continued ethical acceptability of the project;
   - if any complaints are made, or expressions of concern are raised, in relation to the project;
   - if the project needs to be suspended or modified because the risks to participants now outweigh the benefits;
   - if a participant can no longer be involved because the research may harm them.
8. Report on the progress of the project at least annually, or at intervals determined by UHREC (NS 5.5.5);

If any details within this Approval Certificate are incorrect please advise the Research Ethics Advisory Team immediately.

End of Document

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Appendix V

Letter of permission from the Ministry of Education

Ministry of Education

Policy Planning and Research Division

Malé, Maldives

To Whom It May Concern

Approval for collecting information from Schools

This is to inform that Ms. Aminath Waseela, (A054259) who is doing PHD in Education at Queensland University of Technology, Australia, has the permission to collect information required for her research project from the schools of Maldives.

Research Topic

"Teachers' TPACK And Technology Integration In Teaching And Learning: A Case Study In The Maldives."

Main Objectives:

- Investigate Maldivian in-service teachers' knowledge and use of ICT, and its impact on students' cognitive engagement when using digital technologies in classroom environment
- Explore teachers' perception on the factors affecting their use of technology in teaching.

Data Needed:

Online Survey and Interview with participants

Interviewee/s:

Grade 9 and 10 teachers of government schools

Please provide your assistance and support in collecting the information for the research

18 June 2019

Please Note: This research shall be conducted after obtaining written consent from the school management

Velaanaage, 9th Floor, Ameer Ahmed Magu, Malé 20-096, Maldives
Tel: 332 3261, 332 3262 Fax: 332 1201