EXPLORING PRIMARY SCHOOL MATHEMATICS TEACHERS USE OF GAMIFICATION IN FORMATIVE ASSESSMENT: A CASE STUDY

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ABSTRACT

Technology integration has gained much influence with the emergence of technological tools in educational areas. The vast resources and opportunities that technologies and the Internet have brought new approaches, strategies, and tools to assess learners' performance in many subject areas. Teachers have many computer/mobile device applications and learning management systems. Most teachers are trying new ways of integrating technology into the mathematics classroom to increase the quality of teaching and learning. Thus, this study explored how primary school mathematics teachers use Kahoot as a formative assessment tool. The study adopted an exploratory case study underpinned by the interpretive paradigm. It was conducted in a primary school in the Shiselweni Region in Swaziland. The participants were ten mathematics teachers teaching different grades at the school. Data was generated using observations, workshops, structured questionnaires, journal reflections and focus group interviews. The theoretical and analytical framework that underpinned this study was a combination of Davis' (1989) Technology Acceptance Model (TAM) and Mishra & Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework.The study results showed that the perceptions and attitudes of primary school mathematics teachers towards using Kahoot generally appear to be positive. The study also revealed that all the participants found Kahoot helpful and perceived it as easy to use. The study found that the provision of technical support for teachers; and financial support for schools to implement technology use in the classroom were enabling factors for using Kahoot as a formative assessment technology. Constraining factors were lack of high-speed internet connectivity; and lack of basic technological knowledge for using Kahoot in formative assessment. The study concluded that Kahoot increases learner motivation, engagement, attention, enjoyment, and knowledge retention. This study recommended the integration of Kahoot gamification into the mathematics curriculum.The study recommends that there is a need for schools to initiate the presence of technologies in mathematics classrooms and encourage teachers to integrate technologies assessment and teaching. The study suggest future research to explore use of Kahoot as a formative assessment technology in resource-constrained schooling contexts using multiple cases.

Keywords: Teaching, assessment, ICT integration, mediation, Kahoot, gamification, mathematics, TAM, TPACK.

DECLARATION OF ORIGINALITY

I, Simelane Thando, declare that this thesis is my original work submitted at Rhodes University and has not been submitted at any other university. All ideas and citations used in this study derived from other people have been acknowledged and indicated in the list of references.

Signature: 

Date: June 2022

DEDICATION

To my late father, John Myengwa Simelane, and the Simelane Family, I dedicate this thesis to you; anything is possible.

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First and foremost, my sincerest thank you goes to the ALMIGHTY GOD for helping me to survive during this most turbulent period in my life.

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LIST OF ABBREVIATIONS

BI	Behavioural Intention
CK	Content Knowledge
COVID-19	2019 Coronavirus Disease
FGI	Focus Group Interview
GSRS	Game-based Student Response System
ICT	Information and Communication Technology
MoET	Ministry of Education and Training
PCK	Pedagogical Content Knowledge
PEU	Perceived Ease of Use
PK	Pedagogical Knowledge
PU	Perceived Usefulness
SPC	Swaziland Primary Certificate
STEM	Science, Technology, Engineering and Mathematics
TAM	Technology Acceptance Model
TCK	Technological Content Knowledge
TIMSS	Trends in International Mathematics and Science Study
TK	Technological Knowledge
TPACK	Technological Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
TSC	Teaching Service Commission

CHAPTER ONE: SITUATING THE STUDY

1.1 International Context

The use of computers in education has increased dramatically in recent years (Iglesias-Pradas et al., 2021). Now related information and communication technologies (ICTs) are in most classrooms worldwide (Ambusaidi, Musawi, Al-Balushi & Al-Balushi, 2018). This has led to a revolution in education and technology. Thus, contemporary educators conduct teaching and learning using video streaming, 3D printing, artificial intelligence, and interactive whiteboards. On the other hand, educators encounter many problems ranging from infrastructural, high learner-teacher ratios to pedagogical during teaching and learning, where they perhaps avoid or overlook the integration of ICT tools in the classroom. Hence, many countries are making a significant effort to use ICT and allow the opportunity for educators to benefit from technological tools to make the learning process efficient. In addition, most learners are exposed to different technologies, where access to a vast collection of information is readily available (Ali, 2020). Many teachers in the education field assert that technology integration is essential for a school to function effectively. ICT enables teachers to improve their teaching methods and personalise learning. But effective use of technology-based teaching is more likely to show the result of teachers' abilities to design lessons based on robust instructional principles than the technology per se (Dorfman, 2022). Therefore, on this premise, a wide range of literature (Ibáñez & Delgado-Kloos, 2018; Laurillard et al., 2018; Shute & Towle, 2018) has emerged on using technology to assess the learners' conceptual understanding.

Assessing learner progress and attainment of learning objectives is an integral part of any educational system (Bdiwi, 2019; Jung, 2019; Zainuddin, 2020). Assessment practices can facilitate the advancement of educational pedagogical approaches when used appropriately for learners and educators to achieve learning objectives (Wing, 2018). The traditional approach to assessing student learning is through summative methods (Meissner, 2018; Bacquet, 2020; Nieminen, Asikainen & Rämö, 2021). Summative assessment frequently employs standardised exams, quizzes or assignments and subsequently provides quantitative scoring associated with a culminating grade (Ozan & Kincal, 2018). Unlike summative assessment, formative assessment is performed to help students and educators identify and bridge identified current knowledge gaps and make real-time changes in the teaching and learning practices (Ifenthaler et al., 2020). In formative assessment, the teacher provides feedback during teaching and learning, whereby the sole aim is to improve learners' performance.

A traditional way of formative assessment uses paper and pencil quizzes, revision tests, exercises, and question-answer sessions. As such, it is essential to note that, as the learning approaches are integrating technologies (e-learning, mobile learning, flipped learning, and ubiquitous learning); it has become inevitable for the measurement and assessment instruments to incorporate technologies (Wing, 2018; Sad, 2019; Straková, 2019). Within this view, Mailizar and Fan (2020) suggest that teachers should receive technical training to improve their knowledge and skills in using information and communication technology in the classroom to meet learner needs. The COVID-19 pandemic has forced most teachers to integrate and use technologies as a blended learning method of instruction to contain the spread of the virus. It is on this backdrop that this study explores how technology tools such as Kahoot can be used to assess learner performance in education. Kahoot is an assessment tool that resonates like a game show, allowing teachers to monitor their students' progress while they participate in a game (Licorish, Owen, Daniel & George, 2018). Kahoot has many functions that support the teacher conduct summative and formative assessments, and some of these functions are not available in traditional methods of assessing students. For example, Kahoot offers services such as tracking the report and managing performance for each question and time to respond to questions. The teacher or designer of Kahoot games can include various multimedia contents such as pictures or videos in the assessment. Kahoot also allows teachers to select the amount of time that the students have to respond to each question (Pede, 2017; Arif, Zubir, Mohamad & Yunus, 2020). Players in a Kahoot game are awarded points and ranked based on speed and accuracy (Plump & Rosa, 2017). In formative assessment, information and Communication Technology (ICT) has led to a paradigm shift for many teachers.

Technology, such as Kahoot, aid learning and shift learning assessment into a new realm. Technology-enabled examinations can assist in cutting down on the time, resources, and interruption to learning that paper assessment demands (Annamalai & Omar, 2021). Technology-based assessments can give a complete and more nuanced picture of a student's learning needs, interests, and talents than traditional evaluations, allowing the teacher to tailor instructions (Annamalai & Omar, 2021). However, in the classroom, technology is used for many purposes, such as computer-assisted learning (CAL); computer-based learning materials (CBL) (García-Hernández & Kranzlmüller, 2019). It is argued that games are one of the most effective methods to assess learning (De Freitas, 2018). Despite that games have been used as an aid in teaching for many years, some teachers are still not using educational games to measure student learning results (Parra-González et al., 2020). Margot and Kettler (2019) note

most teachers are more likely to use games to teach content than to analyse or grasp what pupils are learning. Papadakis (2018) argues that many games do not target critical learning objectives, are not designed to test students, and do not provide the type of information teachers require in a timely way. Therefore, this study explores how primary school mathematics teachers use Kahoot as a formative assessment tool.

1.2 Background to the Research Context

Over the years, the use of traditional assessment methods in Swaziland schools has created challenges concerning the changing learning needs of students. The case is commonly experienced in mathematics subjects, where teachers fail to assess student's learning progress (Shepard, 2018; Chen, 2020; Wright, 2020). In response, most teachers are slowly trying to integrate technologies into their teaching practices to improve the assessment and teaching practices. This view is emphasised in the Swaziland National Education and Training Sector Policy (2018, p. 26) "Information and Communication Technology should be integrated as a tool for teaching, learning of knowledge and skills development throughout the education and training sector for blended learning". A blended learning environment integrates e-learning with face-to-face interaction (Prasetya et al., 2020). However, most teachers' challenge is integrating technology in assessing learners' learning and knowledge acquisition, particularly in mathematics education (Swaziland National Curriculum Framework for General Education, 2018). Presently, few schools have access to and use technology for formative and summative assessment purposes. Several local studies have been undertaken in search of solutions to the problem, suggested that technology should be integrated into teacher training programs so that teachers can experience and develop technological knowledge and skills to use technology (Madzima, Mashwama & Dube, 2013; Simelane, 2017; Dludlu & Mndzebele, 2018). These studies advocate for ongoing in-service training of educators and learner-centred pedagogies. On the other hand, it has been a challenge for the government to train teachers on ICT integration because of a lack of funding and resources for training (human capacity and technology devices) (Mndzebele, 2018; Salam, 2018; Nath, 2019). Therefore, on this premise, most mathematics teachers continue to prefer the use of traditional assessment methods as they are still not trained on the use of technology in the classroom.

Despite the challenges of assessing learner performance in education and teaching, the importance of adopting and using digital technologies in primary school education should not be underestimated. According to the Swaziland National Education and Training Sector Policy

(2018, p. 26), Information and Communication Technology (ICT) is targeted to teach, learn, school management, and administration. In recent years, some schools in Swaziland have managed to acquire different forms of ICT to support teaching and learning practices. On the other hand, some researchers such as Zwane and Malale (2018); Hamid, Bisschoff and Botha (2015) point out that most teachers in Swaziland schools lack technical knowledge and skills to integrate technology into their practices. Zwane and Malale (2018) note that Swaziland's curriculum and education policies assume that all teachers possess skills and knowledge on using technology in the classroom. This assumption has thus led to little integration of technology in mathematics lessons.

Similarly, the COVID-19 pandemic has brought an unexpected crisis to the Swaziland educational landscape. Schools were closed in March 2020 due to the increase in COVID-19 cases. To overcome the challenge of not attending classes, online and radio learning came into existence. Sinha and Basu (2020) agree that many educational institutions across the globe have decided to shut their traditional classrooms where learners attended lessons in person till the year 2021 or until the COVID-19 pandemic has subsided. To remedy the situation, some schools in Swaziland, during the lockdown, opted to use technologies like Google Classroom and Zoom Meetings. But many teachers lack the opportunity, experience, or knowledge to utilise other technologies that could support them in assessing students' learning within their classrooms (Plump & Rosa, 2021). To make matters worse, accessibility, affordability to the Internet, and lack of access to ICT devices prevented most learners from attending the online learning platforms. Similarly, teachers did not fully realise the benefits and facilities of online learning at the school level worldwide until COVID-19 forced educational institutions to explore the possibilities of teaching or learning online after campus closures (Esampally et al., 2020).

Once again, the education fraternity was hit by the scourge of the third wave COVID-19 pandemic coupled with political uprisings in mid-2021, which forced the entire country to a standstill. The political turmoil that erupted in Swaziland affected the education sector and the social and economic sectors. However, these unprecedented times forced teachers and learners to opt for and adopt technologies that could offer an alternative mode of teaching and learning. Schools that thrived were those that had already been using online learning, but ICT resource-constrained schools were pushed to the margin, thus creating a digital divide. Nevertheless, Swaziland's public schools have been slow to embrace the idea of utilising a curriculum that

prepares students for the 21st century (Nsengimana et al., 2020). A growing body of literature, Simelane (2017); Dludlu and Mndzebele (2018); Esampally et al. (2020), provide insight into Swaziland schools that ICT is used mainly for administrative purposes such as photocopying and printing. Presently, the use of ICT is not common in most Swaziland classrooms. A study conducted by Simelane (2017) found that the lack of in-service ICT training for teachers affects ICT integration in Swaziland classrooms. Thus offering in-service ICT training on the use of ICT in the classroom can bridge this knowledge gap.

1.3 Problem statement

Understanding mathematical operations and concepts for primary school learners are particularly prominent in mathematics classrooms (Herawaty, Widada, Nugroho & Anggoro, 2019; Suharto & Widada, 2019; Testolin, 2020). Learners are expected to learn and correctly use mathematical concepts for more extended periods. The Swaziland Examination Council Report (2020) mentions that mathematics teachers have been encouraged for the past several years to use formative assessment to assess learners' learning targets to help learners achieve learning objectives and to modify instruction as needed to address any misunderstandings. As part of the research, the researcher focused on formative assessment, which a growing body of research shows can significantly impact student learning in the mathematics classroom (Mahdawi, 2019). Formative assessments are used before summative assessments to gauge student understanding and inform instruction. They also provide effective feedback to students and actively involve them in developing their learning. Unfortunately, research shows that effective formative assessments in the classroom are rare in Swaziland (Andersson & Palm, 2017; Wiliam, 2018). Mahmud et al. (2020) argue that mathematics assessments in primary schools encourages students to memorise facts instead of understanding mathematical concepts and processes. Therefore, altering the way mathematics concepts are assessed can profoundly improve a student's ability to become lifelong learners (Boaler, 2019). While searching for formative assessment tools in mathematics, a growing literature (King, 2017; Ismai, Ahmad, Mohammad, 2019; Curto Prieto et al., 2019; ŞAD & Niyazi, 2019) suggest the use of technologies in assessment; hence the study intends to involve Kahoot, which is an engaging gaming-student-response system (GSRS). Kahoot is a technology-based assessment technology with limited research conducted to date within the classroom setting in Swaziland. However, finding a link between its use and students' formative assessment may positively affect teaching and learning mathematical concepts, specifically in the primary classroom. Thus, a gap in practice exists between what research-based literature has shown to be an

effective method to increase student achievement and the current mathematics teacher practices regarding the use of Kahoot in formative assessment in primary schools in the Swaziland context.

1.4 Purpose and significance of the study

This study aims to explore how primary school mathematics teachers use Kahoot as a formative assessment tool. With the increase in the global change towards integration of ICT in the facilitation of learning, this study will provide the selected teachers (participants) and the researcher with technological knowledge on the use of Kahoot as an assessment tool in mathematics lessons. Working collaboratively towards shared goals in a mathematics learning space might equip the participants (teachers) to support one another within, across and beyond schools, as suggested by Ngcoza and Southwood (2019). Similarly, the research will allow teachers to experience Kahoot as a technology to assess the learners in a mathematics classroom. The study's findings will contribute to the literature on how teachers can use Kahoot as a gamification approach to assessing the learners' learning, particularly in the primary school phase and serve as a foundation for future research. Furthermore, the findings will also inform stakeholders in education, curriculum developers and education policymakers in Swaziland on the use of Kahoot as a formative assessment and technology in mathematics lessons and teaching and learning. Lastly, the study will contribute toward filling the knowledge gap that exists in the use of Kahoot as a formative assessment tool in mathematics lessons.

1.5 Research goal/ Objective

The main goal of this study is to explore how primary school mathematics teachers make use of Kahoot as a formative assessment tool. To achieve this goal, the following research questions will be addressed:

1.6 Research questions

1. What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?
2. What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as a formative assessment technology?
3. How can primary school mathematics teachers make use of Kahoot as a formative assessment technology?

1.7 Definition of key concepts

The following terms are defined to assist the reader in comprehending the study.

Assessment – is the process of gathering information to monitor students' prior knowledge and progress and make sound instructional decisions (Wagner et al., 2017).

Blended learning – the thoughtful integration of classroom face-to-face learning experiences with online learning experiences (Bahati, 2019).

Gamification – is the use of game design elements in non-game contexts (Deterding, 2016).

ICT integration - a process of using any ICT (including information resources on the web, multimedia programs in CD-ROMs, learning objects, or other tools) to enhance student learning (Kumar, 2020).

Kahoot – is a student response system that engages students through game-like pre-made or impromptu quizzes, discussions and surveys (Dellos, 2015).

Mediation - the part played by other significant people in the learners' lives, people who enhance their learning by selecting and shaping the learning experiences presented to them (Vygotsky, 1978).

Technology – Wherever technology is used in this thesis, it denotes digital technology that refers to a range of electronic tools, systems, devices and resources that can generate, store or process data and information. Those include devices and means of communication, such as computers, tablets and digital learning tools, and all educational applications that can be found on the Internet (Ravetz, 2020).

TAM – is a model related to technology adoption and focuses on the factors which influence a person's general computer acceptance (Rauniar et al., 2014; Ma & Liu, 2005; Masrom, 2007).

TPACK - is the framework that describes the interplay of three knowledge bases: content, pedagogy, and technology (Mishra & Koehler, 2006; Lee & Kim, 2014; Wang, 2009).

1.8 Overview of the thesis

Chapter One outlines the context, background and purpose of the study. Furthermore, the chapter presents a brief review of literature on the topic to place the study in the Information and Communication Technology field. Lastly, the chapter presents the research goal, the significance of the study, research questions related to research objectives, definition of key terms, and the thesis overview.

Chapter Two presents the literature informing the study. The chapter identifies controversial or debate areas and helps formulate questions that need further research. Again, the chapter relates the study to the larger, ongoing dialogue in the literature and fills in gaps. Furthermore, the literature review was written in a thematic way outlining the themes that the researcher discovered in the study regarding the topic. The chapter ends by critiquing the past research studies related to the study and showing the knowledge gap that exists and warrants this study to be conducted.

Chapter Three discusses the theoretical and analytical framework underpinning this study. The chapter presents the combination of Davis' (1989) Technology Acceptance Model (TAM) together with Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) as the study's theoretical framework. For this study, two constructs of the TPACK framework: Technological Knowledge (TK) and Technological Pedagogical Content Knowledge (TPCK), were used to interpret the generated data for research questions two and three. For research question one, the researcher used the two constructs of the TAM: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). The chapter also reviews the rationale for selecting TPACK as a technology integration framework over other frameworks like SAMR and ACOT. Again, the chapter presents the limitations of TPACK. It also discusses the adoption of the TPACK-In-Action model in this study which underpinned the workshop's design. The rationale for selecting TAM1 over TAM2 and TAM3 is outlined at the end of the chapter.

Chapter Four describes how the research was done and outlines the methods used to collect the data for the study. The chapter begins by presenting the three types of research methods: quantitative, qualitative and mixed methods, then justifying the adoption of the mixed methods research design and interpretive research paradigm in which the study is located. Then the use of a case study as the research style is justified. The discussion then extends to the research site, participants and sampling. Data generation techniques and data analysis methods

employed in this study are also outlined. This was followed by presenting the data triangulation and research evaluation. Lastly, the chapter discusses the ethical considerations adhered to in this study.

Chapter Five presents the findings of the study. Quantitative data collected from structured questionnaires were presented using statistic tables, while qualitative data collected from workshops, focus group interviews, reflective journals and observations were presented thematically. The Technology Acceptance Model (TAM) presented quantitative results, while the Technological Pedagogical and Content Knowledge (TPACK) framework was used to present qualitative results. Some of the themes highlighted in research questions two and three were identified by applying the Technological Pedagogical and Content Knowledge framework. The results of the study, which are consistent with the methodology, are clearly and correctly presented in this chapter. These were a response to the research questions presented in chapter one.

Chapter Six discusses the findings that emerged from the data presentation and analysis. The researcher linked the study findings to the literature reviewed in chapter two and the research questions which guided the study. Previous findings that are consistent with the findings of this study are cited, and those previous findings of this study contradicted are also acknowledged. The research questions were extensively answered, and the conclusions drawn were justified in terms of the methodology. The story that each theme conveyed was discussed considering how they would fit into the broader narrative.

Chapter Seven is the last chapter of the study. The chapter provides a brief overview of the entire study. It presents a summary of the study, a summary of chapters, a summary of key research findings, limitations of the study, conclusion, recommendations for practice, and recommendations for further studies.

1.9 Chapter summary

This chapter placed the study in the Information and Communication Technology field by presenting a brief review of available literature on the topic. This chapter presented the contextual background of the study, problem statement, significance of the study, research goal and questions, definitions of terms and the thesis outline. The next chapter focuses on the discussion of literature relevant to the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The overarching objective of the study is to explore how primary school mathematics teachers use Kahoot as a formative assessment tool. The previous chapter introduced the background context of the study, the problem statement and challenges faced by mathematics teachers that warrant the research, and the goal and objectives of the study. Furthermore, the first chapter introduced an overview of how ICT can be used to enhance teaching and learning, particularly Kahoot as a formative assessment technology. This second chapter reviews the past research studies within the field of ICT-Education that inform the study. The literature review is a critical summary of past research on a topic of interest, often prepared to put a research problem in context (Snyder, 2019). Reviewing literature in this study helped the researcher to establish what is known about the subject area and, by association, what is not yet known (Conde et al., 2021). The literature review accomplishes several purposes in that it identifies areas of controversy or debate and helps formulate questions that need further research (Nguyen & Catalan, 2020). It shares with the reader the results of other studies that are closely related to the one being undertaken. It relates a study to the larger, ongoing dialogue in the literature, filling in gaps and extending prior studies. Further, in this study, the literature review provides a framework for establishing the importance of the study and a benchmark for comparing the results with other findings (Creswell, 2009). To understand the existing research and debates relevant to the use of Kahoot as a formative assessment technology, the chapter draws on the relevant literature to differentiate between formative and summative assessment of learning in education. The chapter further discusses some literature on the use of Information Communication Technology in mathematics education. It also discusses the use of gamification-technology-approach in formative and summative assessment of learning in education; and barriers to using Kahoot as a formative assessment technology in education. Lastly, the chapter presents a critique of the literature.

2.2 Formative and Summative Assessment of Learning in Education

2.2.1 Assessment in Education

The term assessment is used throughout the discussion in this thesis; as such, it is necessary to present its mutual definition. According to Panadero, Andrade and Brookhart (2018), assessment occurs when teachers use evidence of student learning to make judgements on student achievement against goals and standards. It can take the form of teacher questioning,

teacher-developed tasks or tests, high-stakes tests, student portfolios, projects, or performance tasks (Lund & Kirk, 2019; McTighe & Willis, 2019; Chu & Fung, 2020). Steinau et al. (2019) define assessment as the process of collecting information according to systematic and substantively grounded procedures. Tavoosy (2020) expands on this definition and mentions that assessment is a general term that includes all methods used to gather information about learners' knowledge, ability, understanding, attitudes, and motivation. According to Wagner et al. (2017); Chigonga (2020), assessment is gathering information to monitor students' prior knowledge and progress and make sound instructional decisions. These three definitions show that assessment entails collecting information for evaluation purposes. Irons and Elkington (2021) suggest that assessment in teaching and learning should be regarded as a process for obtaining information in curriculum operation to make decisions about student learning, curriculum and programmes, and education policy matters. Furthermore, assessment in the education field has many functions (discussed further in section 2.3), ranging from motivating and grading to evaluating learner feedback.

2.2.2 Formative Assessment of Learning in Education

Formative assessment is often presented differently among education specialists and theorists using different perspectives. Ngafif (2020) identifies formative assessment as a task given to students that aim at helping the learner to evaluate their knowledge and understanding of a specific topic. According to Buelin et al. (2019), formative assessment is essential because it allows teachers to check their learners' progress and teaching effectiveness frequently. Formative assessment is defined by Prashanti and Ramnarayan (2019) as the process of appraising, judging or evaluating students' work or performance and using this to shape and improve students' competence. But Chigonga (2020) argues that a test score as feedback that measures whether a learner has attained the expected standard cannot serve as formative assessment. Teachers need learners' background information in order to modify teaching and learning activities to improve their learning. According to Moss and Brookhart (2019), formative assessment is an ongoing process learners and teachers should intervene to support the learners attain learning goals. What is important to note is the involvement of both the teacher and the learner in formative assessment. Teachers do with learners rather than for learners (Bahati, 2019; Kavanagh, 2020). It is also important to note that formative assessment aims to monitor the instructional process to determine whether or not learning is taking place (Shepard, 2017; Leighton, 2019; Dilova, 2021). However, the strength of formative assessment is remedial in nature in that it improves the teaching and learning process by identifying

challenges met by the teacher and the learner. Teachers then engage in reflection in the pursuit of improving their own practice. What is persuasive from the different scholar's arguments on the purpose of formative assessment is that it provides feedback to the learners and identifies teacher and learner weaknesses to improve learner assessment.

2.2.3 Summative Assessment of Learning in Education

Summative assessment is an evaluation that takes place at the end of the session to measure learners' overall achievement. Annual, internal or external examinations are examples of summative assessment (Bhat & Bhat, 2019; Moeed, 2019; Chigonga, 2020). Similarly, summative assessment collects data after instruction to make judgments about grading, certification, evaluation of progress, or research on effectiveness (Şad & Özer, 2019; Myyry et al., 2021). This means that summative assessment is administered at the end of a course or program. Bahati (2019) argues that summative assessment aims to measure learners' competency and mastery of knowledge. Summative assessment frequently employs the use of standardised exams, quizzes or assignments and subsequently provides quantitative scoring associated with a culminating grade (Wing, 2018; Lipnevich et al., 2020; Peleng'ura, 2020). It is important to note that teachers use summative assessment to grade the learners to certify whether fail or pass. There are numerous advantages of using summative evaluation in the academic arena. These include that the teacher can make out if the learners mastered the subject content, determine achievement, make academic records, and determine the success of methods used for training programs (Wing, 2018; Bhat & Bhat, 2019; Fernandes et al., 2019; Straková, 2019). Worth noting is that summative assessment's fundamental aim is to evaluate learner overall performance, usually at the end of the semester or academic year. The focus shifts to formative and summative assessment functions in education.

2.3 Functions of Formative and Summative Assessment in Education

Formative and summative assessment can serve an informative function in education. This function allows the learner to see his or her achievement and progress in learning. It also lets them see where their performances stand compared to other learners and performances (Lund & Kirk, 2019; Balzer, 2020; Mitchell et al., 2020). I agree with Straková (2019) that classroom assessment plays a crucial role in education. One reason for assessing learners is to monitor academic performance and encourage them to develop their learning. Similarly, Chigonga (2020) agrees that carrying out formative assessments in the form of informal tests, written

classwork, or homework provides continual snapshots of learners' progress throughout the week, month, or school year. The strength of formative assessment is that it places the teacher in a better position to identify the learner's academic performance potential and challenges in a particular subject. For instance, the teacher might reflect on precise topic test results to revise ways that could be used to provide extra support to weak learners. Andrade (2019) corroborates this line of thinking by stating that the informative function of assessment gives the teacher information about the correctness of the chosen strategies for an assessment concerning the given goals. However, one dominant claim emanating from the literature is that formative assessment enables the teacher to see the potential and challenges of the learner's learning progress. This is crucial in the learning process as it points the teacher in the right direction to improve academic results and design a lesson plan that will cater to the learners' individual learning needs.

The corrective function is another important role of formative and summative assessment in education. According to Kumar (2018), the corrective function of assessment enables the student to search, either individually or with help, to improve his or her learning and the direction to take to improve academic performance. Cosi et al. (2020) concur that the students can use the test scores to adjust and improve their own learning using feedback received through formative assessment. I agree with Shepard, Penuel and Pellegrino (2018) because one of the aims of formative assessment is to help learners learn the underlying concepts. This means that the main task of teachers lies in curating the pedagogical challenges experienced by learners in the classroom. However, on this premise, teachers guide the teaching and learning process in the right direction. Research carried out by Watling and Ginsburg (2019) on '*Assessment, Feedback and the Alchemy of Learning'* found that the corrective function emphasises the importance of teachers to facilitate learning rather than directing it. It is associated with resolving students' inquiries, doubts and problems according to their learning rhythms and styles. The teacher advises and makes known the tools, processes and protocols for monitoring and adjustment of the student. But Straková (2019) argues that classroom assessment plays a motivational role in the learners. However, the strength of the corrective function of assessment is that it provides additional information to learners beyond whether or not their answers are correct.

2.4 The use of Information Communication Technology in Mathematics Education

There is no universally acceptable definition of mathematics. According to the seminal work of Pinker (2021), mathematics is the science that deals with the logic of shape, quantity and

arrangement. For the context of this study, I am aligning myself with Yadav (2017)'s definition that mathematics is the scientific study of numbers, including their relationship, operations and measurements expressed by numbers and symbols. Aristotle defines mathematics as the science of quantity (Franklin, 2016). A close inspection of the different mathematics definitions can identify two things: problem-solving and quantities. Mathematics is about numbers and finding solutions to our everyday problems. Certainly, as far as the branch of mathematics is concerned, it is divided into four fields: Arithmetic, Algebra, Analysis and Geometry (Yadav, 2017). The strength of studying mathematics is that it allows the learners to count and calculate; and nurtures their problem-solving skills.

To teach mathematics in the twenty-first century, some researchers suggest that teachers should integrate technologies. ICT has become an integral part and parcel of community and social development, and that shapes the way we live. Technology is defined as applying scientific knowledge for practical purposes (Arif et al., 2019; Ravetz, 2020). Technology applies equally to analogue, digital devices and software (Koehler, Mishra & Cain, 2013). Technology refers to a range of electronic tools, systems, devices, and resources that generate, store, or process data and information. These include devices and means of communication, such as computers, tablets and digital learning tools, and all educational applications that can be found on the Internet (Bahati, 2019). Certainly, technology plays a huge role in people's everyday lives, whether through smartphones, cars, tablets, or computers (Ogudo et al., 2019). Thus based on these arguments, technology deals with sharing and collecting data. By scrutinising the definitions of Ravetz (2020) and Koehler et al. (2013), we note two basic things associated with technology: knowledge and processes. Technology has the potential to be applied in science and a collection of ways of knowing. Likewise, technology can also be defined from the viewpoint of being an object. According to Carroll (2017), technology is inferred to be what is human-made, which is therefore unnatural. What emanates from this definition is that technology is a collection of tools made by human beings for a particular purpose.

Over the last few years, technology of all kinds in education has emerged and has been integrated into teaching and learning practices. Similarly, integrating technology in mathematics teaching and learning has potentially offered teachers and learners to engage in understanding different topics of interest. Christopoulos (2020) argues that educational technology has a proven track record of improving teachers' ability to cover multiple subjects with increasing precision in teaching mathematics. A recent study by Iji and Abah (2018) agrees with Christopoulos (2020) that information technology administered in education can

deliver content instantly, bring distant individuals together in a collaborative community, and make the administrative process faster and easy. Several studies indicated that using technology effectively as a learning tool improves learners' mathematics achievement and motivates learners to learn mathematics (Nasrullah, Marlina & Dwiyanti, 2018; Higgins, Huscroft-D'Angelo & Crawford, 2019; Tokac, Novak & Thompson, 2019; Lo & Hew, 2020). Conversely, for Bucciarelli et al. (2020), Information and Communication Technology minimises the accomplishments of scientific thinking by superficially and mechanically modelling scientific reasoning. To sum up, Bucciarelli et al.'s (2009) arguments that educational technology can enhance teachers' ability to cover multiple subjects with increasing precision is controversial. It is unclear how the different subjects could be covered accurately using technology. However, we owe a debt of credit to previous literature for identifying that technology has the potential to enhance teaching and learning (Rajendra & Sudana, 2018; Uerz, Volman & Kral, 2018; Geng, Law & Niu, 2019). It will be imperative for future research to focus on using new technologies in education to bridge the digital divide gap.

Moreover, technology is essential in teaching and learning mathematics to boost learning motivation. Tohara (2021) argues that technology is a necessary tool for learning mathematics in the 21st century, and all schools must ensure that all their learners have access to technology. Hussein Hakeem Barzani (2021) argues that technology helps learners become independent, proficient members and researchers as increased application of technology will improve learners' understanding of content and develop skills such as problem-solving. According to Ulandari, Amry and Saragih (2018), mathematics education aims to help learners solve the everyday problems of adult life. Since some learners usually become discouraged and easily bored in the mathematics classes, Saadati, Tarmizi and Ayub (2018) highlighted the advantage of using technology as a tool in teaching and learning. This means that introducing a technological device in class can stimulate active learning among learners. Mazana et al. (2019) argue that learners like interesting and fun mathematics lessons. Technology has the potential to enhance engagement and interactions in a classroom. On a similar note, other studies affirm that technology influences the provision of a flexible teaching approach in challenging subjects such as mathematics (McCulloch, 2018; Higgins, Huscroft-D'Angelo & Crawford, 2019; Putnam, 2020). In a nutshell, the different scholars argue that technology can assist in mathematics lessons by motivating the learners to learn. Thus contemporary educators should stay abreast with newer digital technologies, which change frequently. Research has revealed

some constraints despite the affordances of technology use in teaching and learning mathematics.

One constraint of technology use in the teaching and learning of mathematics is that the success of technology integration is wholly dependent on the teacher's proficient technical knowledge and skills. Ahmadi and Reza (2018) affirm that even though the ICT may promote educational change, the effective use of technology is truly dependent on the teacher's technical knowledge of integrating ICT in the classroom and how learners can access the new technologies and be encouraged to use them as learning tools. As the teacher is responsible for creating a conducive learning environment in the classroom, it is imperative that he or she is technology-conversant to use technology during the teaching and learning process. A study by Harris and Koehler (2009) on '*Teachers' Technological Pedagogical Content Knowledge and Learning Activity Types'* found that many teachers earned degrees when educational technology was at a very least stage of development than it is today. Thus, it is not surprising that teachers do not consider themselves sufficiently prepared to use technology in the classroom. They often do not appreciate its value or relevance to teaching and learning. Therefore, the different scholars' views suggest that the learning process is reliant on the teacher. Thus, it is imperative to train teachers on emerging educational technologies. According to Kesharwani (2020), most learners in developing and developed countries are digital natives, able to use the technology and live with it, compared to the older generation who are learning and adopting new technology as digital immigrants. Therefore, to close the teacher's incompetence in using a particular technology in class, the learners who are digital natives should be included in the planning and integration of technologies in the classroom.

2.5 The use of Gamification Technology Approach (technology-based games) in Formative and Summative Assessment of Learning in Education

Over the years, the world has experienced the gradual development of Information and Communication Technology. The ICT diffusion has also been noted in education, particularly teaching and learning. For instance, some teachers have incorporated technology-based games to present teaching and learning and construct knowledge socially. The idea of including games or the gamification approach in teaching and learning is not a new trend; from an early age, learning was through different types of play, whether it is playing with friends, playing a sport, cards or board games, games engage and capture our attention (Kasurinen & Knutas, 2018). However, many definitions of gamification have been formulated over the years. Therefore, for this study, the researcher will use Deterding's (2016) definition, which is the use of game

design elements in non-game contexts. But Huotori and Hamar (2012), as cited by Forsberg (2018), define gamification as a process of providing affordances for gamefic experiences which support the customer's overall value creation. Nguyen and Yukawa (2019) concur that a game is an activity with rules, a goal and an element of fun.

The gamification approach can be used in education to assess the learners for conceptual understanding. For example, in terms of the benefits of online testing, gamification has been used in basic assessment methods by automated computer tests and quiz marking (Nguyen & Yukawa, 2019; Owens et al., 2020; Jaiswal, 2020; Bahari, 2021). The weakness of using technology as an assessment tool is that learners may answer questions without careful consideration. But the strength is that it can increase assessment efficiency by enabling automatic marking hence reducing the workload on the teacher. If the learners get instant feedback, they will be motivated, and self-learning will be promoted. This line of thinking is corroborated by Al-Hadithy and Ali (2018), who argue that the quicker, clearer, and more relevant the feedback for formative assessment, the higher the likelihood that learners will apply that feedback to the information learned and modify knowledge and understanding that may not have been completely mastered.

The gamification approach is used to enhance the learners' problem-solving skills. A game is nothing but a set of problems to solve. Many games encourage creative and varied problem-solving skills. The problems or challenges that a game offers should facilitate a situation where the players can use the tools at their disposal to solve the problem efficiently (Zakia, 2019; Czauderna & Budke, 2020; Chen et al., 2020; Janakiraman, 2021). These sentiments were corroborated by Licorish et al. (2018), who argue that educational games as learning tools (e.g. video games) support the development of learners' cognitive, motivational, emotional and social outlooks. Krath, Schürmann and von Korflesch (2021) maintain that critical thinking can be reinforced because games can provide various creative opportunities and examine problems from multiple perspectives. This demonstrates that children practise and develop skills central to their learning through educational gamification. Al-Hariri and Al-Hattami (2016) added that increased technology implementation will increase learners' comprehension of content and develop analytical reasoning, problem-solving, information evaluation, and creative thinking skills. Critical thinking is imperative because it places the learners in a better position to analyse and solve their pedagogical problems. But Pektas and Kepceoglu (2019) argue that if learners do not like the application, they can lose their motivation. This can negatively impact their learning as they will not exert their total effort, time, and energy on the task at hand.

A recent study by Ting, Lam and Shroff (2019) on '*Active Learning via Problem-Based Collaborative Games in a Large Mathematics University Course'* found that mathematics is often taught purely using the lecture format, which encourages passivity and diminishes learners' creativity. Therefore, it is on this backdrop that using a gamification technology such as Kahoot in mathematics is vital as it exposes the learners to problem-solving scenarios. Problem-solving skills can offer the learners the opportunity to solve real-world problems. In that regard, what is more persuasive from the different authors' arguments is that educational games strengthen essential skills for learning. The strength of this argument is that the learners might become better decision-makers if they think critically. The next section focuses on using Kahoot as an assessment technology in education.

2.6 The use of Kahoot as a Formative Assessment Technology in Education

Over the years, the education sector has experienced the integration of technology games, and one of the prominent technologies is Kahoot. Kahoot is a simple game that involves players who play educational related game-based content. In order to play, Kahoot players (learners) use electronic devices and the Internet. In the context of this study, Kahoot is presented as an online quiz program that is free, easy to set up and use and fosters learning in a group setting. Kahoot is a game-based student learning and response system capable of changing the classroom dynamics into a game show (Singh, Ganapathy & Lin, 2019; Jones et al., 2019; Tran et al., 2019). During Kahoot gameplay, the learners go through game-like pre-made or impromptu quizzes, discussions and surveys (Dellos, 2015). In a Kahoot driven lesson, the teacher plays the role of a game host, and the learners will be engaged in terms of competing with one another to be on the scoreboard. Learners can read the questions on their devices or on the teacher's computer connected to a large screen that displays questions and possible answers. In contrast, the learners give their answers as fast and correct as possible on their own digital devices (Singh et al., 2019). Kahoot games allow the incorporation of graphics, audio, file sharing, and performance monitoring features. In addition, the learners join the game via a specifically generated game code and can create their nicknames to be displayed on the game screen (Pede, 2017). In general, Kahoot can be used in all subjects, and it can support the learning process by engaging and motivating the learners. What is important to note from the different definitions of the term Kahoot is that it is an online multiple-choice game that is free and easy to use, fostering group interaction. The strength of group interaction in the classroom is that it creates a positive atmosphere and promotes learner motivation and engagement.

The use of Kahoot as a formative assessment technology offers opportunities to create efficiency in assessing learning and improving learning outcomes. Kahoot can be time-saving in preparing the assessment, tracking learners' understanding, and delivering instant feedback. Attesting to this view, Nguyen and Yukawa (2019) state that Kahoot saves teachers' time by including different creative activities in the assessment. Tran et al. (2019) corroborated this idea that learners' performance can be tracked, which significantly helps teachers with the assessment process. The benefit of monitoring learner progress is that it allows the teacher to evaluate their own teaching effectiveness. But a big challenge for using Kahoot as an assessment tool in the classroom is that the learners will get bored of doing the same thing every day. Pede (2017) affirms that one possible drawback of the popularity of Kahoot is the concern that learners will begin to get bored of playing the same game. This view holds that monotony can strike at some point during the learning process. Kahoot game offers competition among the learners (players); hence the disparity in the scoreboard might diminish the will to play if a learner continuously loses. Lastly, one dominant claim emanating from the different literature is the issue of boredom. This might dampen the learners' zeal to play; thus, future research should address this impending problem.

The use of Kahoot as a formative assessment technology in the classroom can promote collaboration among the learners. This aligns with the concept of social interaction propounded by Vygotsky (1978), which holds that human learning is a social process and that human intelligence originates from culture and society. For instance, Nguyen and Yukawa (2019) argue that Kahoot is designed to provide learners with collaboration in studying to promote learning motivation. Pektas and Kepceoglu (2019) share the same sentiments that Kahoot generates collaboration among learners. The strength of collaboration is that it encourages sharing ideas among the learners; hence, they learn from each other. Communication and critical thinking skills are also sharpened through the gameplay. But the limitation of working together during a Kahoot game is that learners might shun teamwork to maintain their winning pace. Therefore, according to Singh et al. (2019), playing games harmonises the class and leads to learners' academic achievement, motivation, and classroom dynamics. On this premise, collaboration is vital in the classroom, as it might promote skills such as communication and problem-solving. But the gameplay has suffered under misconceptions of being easy, irrelevant to learning, and applicable only to young children (Yücel & Rızvanoğlu, 2019). Collaboration during the learning process increases the learners' attention, creating a fertile learning environment.

Another use of Kahoot as a formative assessment technology in education is that it can promote learner engagement. Singh et al. (2019) argue that Kahoot utilises playful and colourful visuals and audio to promote learner engagement. In my observation, visuals are important to learners as they can arouse learning interest. Similar sentiments were shared by Licorish et al. (2018), who maintain that the use of Kahoot triggers positive attention and focus in the classroom. İbili et al. (2020) argue that learners' level of understanding of concepts heightened when allowed to work cooperatively. Tran et al. (2019) assert that Kahoot significantly improves learner engagement and organises valuable data in learner assessment and performance. But critics of Kahoot believe that a learner who gives consecutive wrong answers may lose self-confidence and feel demotivated in the classroom (Pektas & Kepceoglu, 2019). If the learners are engaged during the learning process, their attention will be increased. Conversely, a recent study by Angkotasan, Tonra and Taib (2019) on *'The Excess of Kahoot for Pre-Service Teacher as an Evaluation Tool'* found that the scoreboard on a Kahoot game makes the learners nervous when their answer is wrong. Therefore, if the learners are nervous, they might not comprehend what is being assessed. Also, learners' motivation is vital in the learning process because it energises them to learn the underlying concept. Despite the many benefits of using Kahoot as a formative assessment technology, it also has some challenges.

2.7 Barriers of using Kahoot as a Formative Assessment Technology in Education

There are many barriers to using Kahoot as a formative assessment technology in education. Roesch-McNally et al. (2018) define barriers as challenges that have to be overcome to attain a goal. Horváth and Szabó (2019) define a barrier as any condition that makes it difficult to make progress or achieve an objective. Many scholars have tried to explain the possible contributors to the use of Kahoot in the classroom. Castro (2016) classified barriers as falling into two primary categories, namely, extrinsic (first-order) and intrinsic (second-order). Extrinsic barriers include lack of resources, inadequate training, insufficient technical support, and lack of time. Intrinsic barriers, on the other hand, include teachers'/instructors' beliefs, visions concerning technology integration, and views about teaching, learning, and knowledge. Technology is increasingly being used in the classroom for instruction. As schools move forward into the digital age, educators should incorporate technology into their classrooms wherever possible (Pede, 2017; Plump & Rosa, 2017; Arif et al., 2019). For instance, technologies like Kahoot can engage the learners and create a collaborative learning

environment in class. However, research has shown that it can have some challenges, as highlighted in the next paragraph.

Slow Internet connections and lack of electricity can be a drawback when using Kahoot in the classroom to assess the learners' learning and content knowledge. Many researchers argue that the downside of this game-based learning application is getting connected to the Internet, whether to create the game or to play the game in the classroom (Zarzycka-Piskorz, 2016; Sabandar, Supit & Suryana, 2018; Tran et al., 2019). Though Kahoot enables social interaction and discussions between class members, if a connection to the Internet is poor or slow, the user will lose game play and access to the game (Zakia, 2019). Thus, it is imperative to have power back up to keep the Kahoot game going even during a power cut. Studies by Tran et al. (2019) and Hitchens and Tulloch (2018) argue that another problem comes from the technical issue when students cannot get back into the game once they lose their connection during the game, easily causing an attrition war. Ultimately, when utilising Kahoot as an evaluation tool, there is also a barrier faced by some learners, that is, the Internet connection that must always be available and accessible to allow the learners to play the game (Angkotasan et al., 2019). There are also other drawbacks such as technical problems, unreliable internet connections, slow to read questions and answers on a projected screen, not being able to change an answer after submission, stressful time pressure for giving answers, not enough time to answer, afraid of losing, and hard to catch up if an incorrect answer had been given (Wang & Tahir, 2020). What is more persuasive from the different author's arguments is that a strong Internet connection is required for a Kahoot-driven lesson to be successful. Thus, power cuts might fail the spirit of the game; hence the learners might be demotivated.

Moreover, the competitive nature of games can make the learners more interested in winning than comprehending the questions. In a similar discourse, the learners being aware of an expectation for a quick response may guess or answer questions without thorough consideration (Licorish et al., 2018; Zakia, 2019; Li et al., 2020). Though Kahoot allows the shy learners to answer questions without embarrassment, the learners might make a lucky guess on a question then the teacher might assume they understand the concept being assessed. This might place the teacher in a weak position to provide the necessary guidance to the learners experiencing difficulties. Conversely, games are considered effective learning aids because they spur motivation and learners get very absorbed in the competitive aspects of the games. Moreover, learners try harder at games than in other courses (Nguyen & Yukawa, 2019; Jones, 2019; Singh, Ganapathy & Lin, 2019). This demonstrates that games promote student

engagement in the classroom. Barbosa and de Ávila Rodrigues (2020) added that gamification might absorb teacher resources or teach learners that they should learn only when provided with external rewards. Therefore, the learners might cease putting effort into their learning once the reward is no longer available.

2.8 Critique of the Literature

Kahoot is a technology-based instructional tool with limited research conducted to date within the classroom setting in Swaziland. However, finding a link between its use and learners' formative assessment may have positive implications in the teaching and learning of mathematical concepts, specifically at the primary school level. Thus, a gap in practice exists between what research-based literature has shown to be an effective method to increase learner achievement and the current mathematics teacher practices regarding the use of Kahoot in formative assessment in primary schools in the Swaziland context.

Literature focusing on the use of Kahoot in the classroom as a formative assessment technology writing tends to consist of large-scale, quantitative studies based on Likert Scale questionnaire data. These studies are usually informed by the quantitative research designs (Plump & LaRosa, 2017; Głowacki, Kriukova & Avshenyuk, 2018; Supit & Suryana, 2018; Kapsalis, Galani & Tzafea, 2020; Sánchez et al., 2020). Authors usually use the positivist paradigm to solve problems using numeric or statistical analysis within this research approach.

Being large-scale, studies about the use of Kahoot for formative assessment in the classroom provide reliable results. The larger the sample size, the more precise the mean. These studies usually use the positivist paradigm, which is based on the assumption that a single tangible reality exists—one that can be understood, identified, and measured (Park, Konge & Artino, 2020). For instance, research by Pozo Sánchez et al. (2020) on '*Gamification as a Methodological Complement to Flipped Learning'* used a quasi-experimental design (a type of research design that attempts to establish a cause-and-effect relationship); therefore, it used only highly structured research instruments to gather data. This study uses the mixed methods research approach to triangulate data and to understand the research problem better.

While providing valuable explanations for the causal relationship among Kahoot and student performance in the classroom, experimental studies do not provide an actual explanation. Experimental research typically uses highly structured research instruments such as the Likert scale to collect participants' attitudes and opinions. For example, by rating participants' perceptions to strongly agree, disagree, undecided, agree, and strongly disagree, empirical

researchers are not able to answer the question of "Why" using their research findings. Therefore, while experimental research allows cause and effect to be determined, such studies are subject to human error. Participants might give answers not based on how they truly feel but on what they think the researcher wants to hear.

Due to the relevance of technology integration in education, many studies have investigated the matter from different aspects. However, as technology is an ever-changing phenomenon, it requires continuous research. While many studies have focused on investigating the use of Kahoot to boost learner engagement and motivation during the teaching and learning process (Zarzycka-Piskorz, 2016; Pede, 2017; Licorish et al., 2018; Nguyen & Yukawa, 2019; da Silva, Rodrigues & Leal, 2019; Singh, Ganapathy & Lin, 2019) little has been done on the use of Kahoot as a formative assessment tool in mathematics lessons in primary schools in particular. These sentiments are corroborated by Repes (2016), who argues that the use of Kahoot as a formative assessment technology would benefit both learners and teachers. Furthermore, most of the studies reviewed in this thesis were conducted in western countries and less in Africa. As such, literature lacks empirical research concerning the use of Kahoot in an education setting in developing countries like Swaziland and Africa. This study aims to bridge this gap in existing research. Furthermore, the seminal work of Yildirim and Sadik (2021) *Using Kahoot as a Multimodal Tool: A Literature Review* found that Kahoot is used for assessing students' performances, reviewing their knowledge, or as a new path to change traditional classroom activities. Yildirim and Sadik (2021) is a desktop research it took less time to conduct. The limitation of a desktop researcher is that the researcher does not have control over the participants and research methods.

Much of the current literature agrees that Kahoot can increase learner engagement, motivation, and concentration in a classroom when assessing learners' content understanding. Gamification has become an integral modern tool of education in the 21st century that teachers in the classroom can use to serve as a means of enhancing motivation and engaging learners to learn (Plump & Rosa, 2017; Aktekin, Çelebi & Aktekin, 2018; Głowacki, Kriukov & Avshenyuk, 2018; Arif, Zubir, Mohamad & Yunus, 2019; Wang & Tahir, 2020). And this is commonly attributed to gamification, as it makes the learning process more attractive to learners (Angkotasan et al., 2019). Undoubtedly, a study conducted by Pozo Sánchez et al. (2020) on '*Gamification as a Methodological Complement to Flipped Learning'* found that, the application of gamification as a didactic strategy causes an increase in the positive values of learner development. It considers the change of rewards for the typical qualifications, giving

the learners freedom in the training process, eliminating their fears of making mistakes, and making them the protagonists of the follow-up to their training. Pozo Sánchez et al. (2020) used a quasi-experimental design of descriptive and correlational type based on a quantitative methodology of data processing. They aimed to establish the cause-and-effect relationship between the experimental and control group. This study adopted the mixed methods approach, quantitative and qualitative data were collected concurrently to understand the research problem better.

What has been observed from previous studies on educational gamification is that there is extensive evidence from the literature that Kahoot improves learner engagement, interaction, understanding and academic results. However, it is within this view that this study intends to understand further the empirical experiences of using Kahoot in the primary schooling context, as most previous studies researched on Kahoot with high school and university students, whereas primary education forms the basis for education. For instance, Arif et al. (2019) researched on '*Benefits and Challenges of Game-Based Formative Assessment among Undergraduate Students'* using the Connectivism Learning Theory. Connectivism Learning Theorists argue that the use of digital technology helps to solve a problem. Arif et al. (2019) were blinded by the theory; since connectivism is a relatively new and emerging learning theory, formal literature on the topic is limited. It is also argued that it is not a learning theory but a pedagogical theory (Downes, 2022). This study uses TPACK and TAM as theoretical lenses to support each theory's limitation and better understand the research problem.

2.9 Chapter summary

This chapter, therefore, presented the literature related to the study. It started with discussing formative and summative assessments of learning in education. Then, it went on to highlight the use of Information Communication Technology in mathematics education. Furthermore, the use of gamification-technology approach in basic education was discussed; and the discussion was extended to the use of Kahoot as a formative assessment technology in teaching and learning. This was followed by a discussion on barriers to using Kahoot as a formative assessment technology in education. Lastly, the chapter presented a critique of the literature. The researcher discusses the theoretical framework underpinning the study in the next chapter.

CHAPTER THREE: THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Introduction

This chapter discusses the theoretical and analytical framework underpinning the study. The theoretical framework that underpins this study is a combination of Davis' (1989) Technology Acceptance Model (TAM) together with Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework. These theories were not enough to inform this study; hence, they are used jointly to complement one another. This chapter starts by discussing the basic concepts of a theoretical framework. Then the discussion is extended to the TAM and TPACK framework, respectively. Lastly, the constructs of the TPACK framework that informs the interpretation of data are discussed.

3.2 Theoretical framework

A theory is a set of interrelated constructs (variables), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables, to explain natural phenomena (Creswell, 2009). It is an overall perspective from which one sees and interprets the world (Abend, 2008). Thus theories are nets to catch 'the world', rationalise, explain and master it (White, 2017). A theoretical framework is a logically developed and connected set of concepts and premises - developed from one or more theories that a researcher creates to scaffold a study (Varpio, Paradis, Uijtdehaage & Young, 2020). It is the 'blueprint' or guide for research (Grant & Osanloo, 2014). It comprises the theories expressed by experts in the field of specific research to provide a theoretical *coat hanger* for data analysis and interpretation of results (Kivunja, 2018). Thus a theoretical framework is a structure used by researchers to make the bits and pieces of data hang together as one body of knowledge. In addition, Varpio et al. (2020) argue that subjectivist inductive research does not begin with a hypothesis; instead, the study starts with a desire to understand or explain a particular phenomenon. The researcher collects data about the phenomenon and searches for patterns across the data to generate an understanding. A theoretical framework enhances the credibility and confirmability of qualitative data or the internal validity of quantitative data (Kivunja, 2018). Two theories underpin this study: Davis' (1989) Technology Acceptance Model (TAM) together with Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge

(TPACK) framework, **see Figure 1** below. Furthermore, the arrows used below show the direction of the hypothesized relationship between two variables.

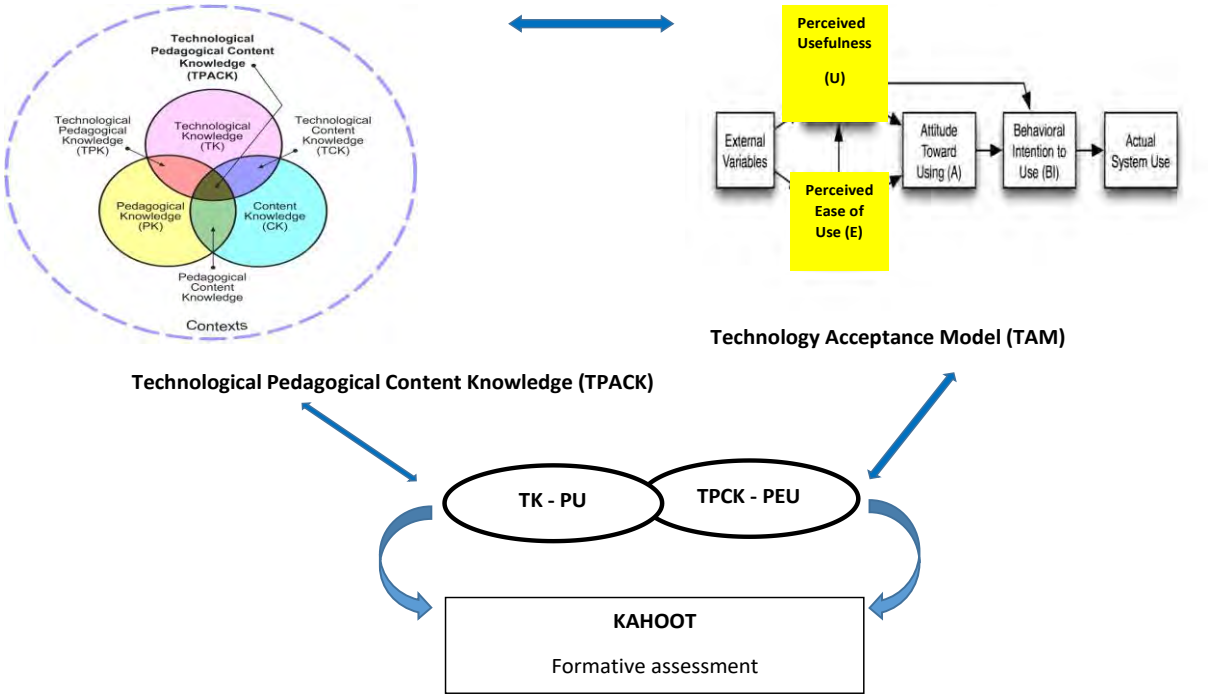


Figure 1: The components of TPACK and TAM

3.3 The Technological Pedagogical Content Knowledge (TPACK) framework

Technological Pedagogical Content Knowledge (TPACK) is the framework that describes the interplay of three knowledge bases: content, pedagogy, and technology (Mishra & Koehler, 2006; Wang, 2009; Chai, Koh & Tsai, 2013; Lee & Kim, 2014; Schmidt-Crawford & Jin, 2018; Taopan, Drajati & Sumardi, 2020). TPACK is contextualised knowledge that integrates technology and pedagogy on specific content knowledge (Lin et al., 2013). TPACK was introduced to the educational research field as a theoretical framework for understanding teacher knowledge required for effective technology integration (Mishra & Koehler, 2006; Schmidt et al., 2014). The TPCK framework acronym was renamed TPACK (pronounced "tee-pack") to make it easier to remember and to form a more integrated whole for the three kinds of knowledge addressed: technology, pedagogy, and content (Schmidt et al., 2014). Within the framework, teachers' professional development of technology integration should go beyond just technology; the integration of technology, pedagogy, and content is emphasised (Mishra & Koehler, 2006; Mishra & Koehler, 2009). The TPACK framework builds on Shulman's

(1986, 1987) descriptions of PCK to explain how teachers' understanding of educational technologies and PCK interact with one another to produce effective teaching with technology (Koehler, Mishra, & Cain, 2013). TPACK is a framework that introduces the relationships and the complexities between all three basic components of knowledge: technology, pedagogy, and content. It is an intuitive understanding of content with appropriate pedagogical methods and technologies (Schmidt et al., 2014. Equally crucial to the framework are the interactions between and among these bodies of knowledge, represented as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK (technology, pedagogy, and content knowledge) (Koehler et al., 2013). Moreover, the concepts of TPACK, particularly the Technological Knowledge (TK) and the Technological Pedagogical Content Knowledge (TPCK), will inform the lens to understand the phenomenon of interest in the study. The combination of TPACK with the Technology Acceptance Model (TAM) as a theoretical lens for the study allowed the researcher to understand the research problem better. In the context of this study, two constructs of TPACK (TK and TPCK) are essential to address the research problem. In the framework, the three unitary types of knowledge are pedagogy knowledge (PK), content knowledge (CK), and technology knowledge (TK). The three knowledge constructs are explained below:

3.3.1 Pedagogical Knowledge (PK)

Pedagogy is the art of teaching. It includes teaching strategies, techniques, or approaches that a teacher uses to deliver instruction, facilitate learning, and assess students' understanding (Wang, 2009). Pedagogical Knowledge (PK) refers to the teacher's knowledge and use of the general pedagogical activities in teaching and learning (Cox & Graham, 2012; Lye, 2013). Thus, PK is knowledge of the processes and practices or methods of teaching and learning, including classroom management, development and implementation of lesson plans, as well as student assessment (Mishra & Koehler, 2006; Lin et al., 2013; Schmdt et al., 2014; Lee & Kim, 2014). This knowledge includes teaching strategies for addressing individuals' learning needs and methods of presenting the subject matter (Erdogan & Sahin, 2010; Sahin, 2011). In other words, it refers to the practice, procedure, or methods necessary for teaching and learning (Koehler et al., 2007). For instance, this knowledge consists of general classroom management strategies, course planning, and student assessment.

3.3.2 Content Knowledge (CK)

According to Shulman (1986), content knowledge (CK) is the amount and organisation knowledge teachers must master to be effective. Therefore, Mishra and Koehler (2006) built

on this definition and argued that CK is knowledge of the actual subject matter to be learned or taught, including central concepts, theories, and organising or connecting ideas. CK is simplified to indicate a knowledge of the possible topic-specific representations in a given subject area (Cox & Graham, 2012). It is subject-matter knowledge such as scientific knowledge (Lin et al., 2013). Teachers must know about the content they will teach and how the nature of knowledge is different for various content areas (Schmidt, 2014). This knowledge is about the teacher's subject area (Koehler et al., 2007). In other words, it answers the question of "what will be taught?" (Sahin, 2011). It includes terms, theories, ideas, constructs, and applications specific to a content area (Shulman, 1986), such as math, biology, and history. An individual without this knowledge may have misconceptions or misleading facts regarding the area (Koehler & Mishra, 2009). Building on Shulman's (1987) assertion concerning pedagogical knowledge, Koehler and Mishra (2005) introduced the conceptual framework of integrating educational technology into pedagogy.

3.3.3 Technological Knowledge (TK)

Technology knowledge (TK) is constantly in flux (Koehler & Mishra, 2009). It includes all instructional materials from blackboard to advanced technologies (Koehler et al., 2007; Sahin, 2012; Lye, 2013). In general, it refers to various technologies used in learning environments. Technology knowledge (TK) refers to the knowledge about different technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs (Schmidt, 2014). TK is the knowledge of the standard and advanced technologies, including the skills to install, remove and operate particular technologies (Mishra & Koehler, 2006; Baran, Chuang & Thompson, 2011; Kim, 2018). The definition of TK used in the TPACK framework is close to that of Fluency of Information Technology (FITness). FITness goes beyond traditional notions of computer literacy to require that persons understand information technology broadly enough to apply it productively at work and in their everyday lives, to recognise when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology (Koehler & Mishra, 2009). For Lin et al. (2013), TK is the general knowledge of emerging technologies, such as using blogs and multiple-touch mobile devices. The TK construct is imperative for this study as the study is based on the use of Kahoot as a formative assessment technology. For instance, a teacher must connect a projector to a computer, surf the Internet, and create Kahoots, to list a few. In addition, the TPACK framework has the three dyadic components of knowledge: technological pedagogical

knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK). These types of knowledge are explained next:

3.3.4 Technological Content Knowledge (TCK)

Technological Content Knowledge (TCK) is the knowledge of how technology and content relate to, influence, and constrain each other (Koehler & Mishra, 2009). Harris and Hofer (2011) built on this definition and pointed out that TCK means selecting technologies that best embody and support particular content-based precepts. Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that they can change the way learners practice and understand concepts within a particular content area (Schmidt et al., 2014; Salavati, 2016; Kim, 2018). This knowledge includes all instructional materials from blackboard to advanced technologies (Koehler et al., 2007), which help teachers visualise instances in which technology can be effectively integrated into their teaching (Erdogan & Sahin, 2010). It refers to various technologies used in learning environments (Sahin, 2011).

3.3.5 Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge (TPK) is the knowledge of the capability of various technologies, including affordances and constraints that influence pedagogical designs and strategies in teaching and learning settings (Koehler & Mishra, 2009; Lye, 2013). It is simply the knowledge of how to use particular technologies in teaching (Harris & Hofer, 2011), which requires an understanding of general pedagogical strategies applied to the use of technology (Erdogan & Sahin, 2010). In a similar discourse, it involves an understanding of how teaching and learning will change with the use of specific technologies. It consists of integrating technological tools and equipment with appropriate instructional designs and strategies by realising their strengths and limitations. Most popular computer software is not designed for educational purposes (Koehler & Mishra, 2009). For Cox and Graham (2012), TPK is a knowledge of the general pedagogical activities that a teacher can engage in using emerging technologies. Thus, in this study, TPK includes knowledge of how primary school mathematics teachers assess learners' conceptual understanding using Kahoot.

3.3.6 Pedagogical Content Knowledge (PCK)

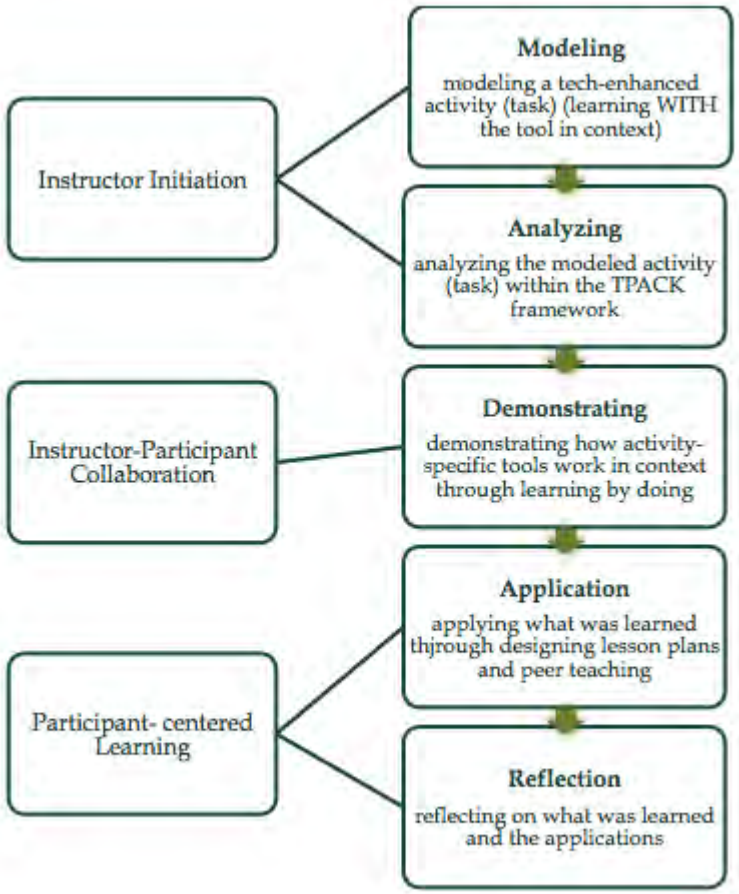
According to Shulman (1986), Pedagogical Content Knowledge (PCK) is about how to teach specific content-based material. This knowledge includes knowing what teaching approaches fit in the content and how content elements can be arranged for better teaching (Mishra & Koehler, 2006). PCK refers to teaching knowledge applicable to a particular subject area (Harris, Mishra & Koehler, 2007; Lee & Kim, 2014; Knolton, 2014; Brueck & Lenhart, 2015; Salavati, 2016; Kim, 2018). Knowledge of pedagogy is applicable and appropriate to teaching specific content (Koehler & Mishra, 2009). Pedagogical content knowledge is different from various content areas as it blends both content and pedagogy, intending to develop better teaching practices in the content areas (Lye, 2013; Schmidt et al., 2014). However, as the framework's core, TPACK is the intersection of the three knowledge bases: Technological Pedagogical and Content Knowledge (TPACK). TPACK is the knowledge of how a tool can be used – its features, affordances, and constraints – to uniquely support students' learning of a given curricular topic or concept (Forssell, 2011). It is imperative to note that each and all of these types of teacher knowledge are influenced by contextual factors, such as culture, socioeconomic status, and school organisational structures (Harris & Hofer, 2011). This study adopted the TPACK-In-Action Model (Tai, 2013). This model is framed within Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006) and advocates a 'learning-by-doing' approach to understanding how primary school mathematics teachers use Kahoot to formatively assess learners' content knowledge.

3.4 TPACK-In-Action model

This study adopts the TPACK-In-Action model to guide the workshop's design in helping primary school mathematics teachers develop their TPACK proficiency and integrate technology (Kahoot as a formative assessment tool) in their classrooms (Tai, 2013). This model is framed within Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006) and advocates a learning-by-doing approach to understanding how primary school mathematics teachers use technology to formatively assess learners' content knowledge. Thus, the TPACK-in-Action model proposes that a workshop follows these five steps: a) Modelling; b) Analysing; c) Demonstrating; d) Application; and e) Reflection to achieve the intended goal of helping mathematics teachers develop the competency needed to integrate technology (the expertise of using Kahoot as a formative assessment tool discussed further in the literature review section) into their classroom teaching (Harris & Hofer, 2011; Koh, Chai & Tay, 2014; Tai, 2015; Bibi & Khan, 2017).

Thus, the researcher held workshop discussions with primary school mathematics teachers in this study's context. First, the workshop started with *modelling* activity to situate teachers in context (Tai & Chuang, 2012). During this first step, teachers had the opportunity to witness how Kahoot is used as a formative assessment tool to assess learner content knowledge. They saw the importance of technology integration in their teaching and the usefulness from a practical task perspective. This is also known as the Perceived Usefulness (Deslonde & Becerra, 2018), discussed further in the Technology Acceptance Model below. The second step is *analysis*, acknowledging the notion that teachers need to know how to use technology and understand why they are doing so (Tai, 2012). This activity supported that the selected teachers understand the rationale behind the choice of technology and pedagogy incorporated into the content in the modelled activity (Tai, 2015; Bibi & Khan, 2017). The third step is *demonstrating,* whereby teachers learn about features of tools incorporated into the modelled activity. The researcher demonstrated to the teachers how to use Kahoot as an assessment tool and play the Kahoot game. The next step is *application,* where the researcher provided the teachers with the opportunity to apply what they learned in the workshop (Harris & Hofer, 2011; Sulaimani, Sarhandi & Buledi, 2017). For instance, teachers created their Kahoots using a variety of media. They received peer feedback and support before using Kahoot to assess learner content knowledge in mathematics class. The final step is *reflection,* where teachers reflected on their experiences of participating in the workshops and using Kahoot in the formative mathematics assessment (Coughlan & Coghlan, 2002; Tai & Chuang, 2012; Kemmis, Mctaggart & Nixon, 2013).

Figure 2: TPACK-In-Action model adapted from Tai (2015)



In this study, the TPACK framework is used in conjunction with the Technology Acceptance Model. The combination of TPACK with the Technology Acceptance Model (TAM) as a theoretical lens for the study allowed the researcher to understand the research problem better. In the study's context, two constructs of TPACK (TK and TPCK) and two constructs of TAM (PU and PEU) are essential to address the research problem. For instance, the development of TK made the teachers involved in the study believe that using Kahoot can improve the way they do formative assessments in mathematics lessons. At the same time, the TPCK helped the teachers to perceive how easy it is to use Kahoot.

3.5 Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) is broadly accepted and has proved applicable in identifying consumers' willingness to utilise information and communication technology (ICT). The theory proposes that Perceived Ease of Use (PEU) and Perceived Usefulness (PU) are determining factors of individual attitudes. In contrast, attitude is a determining factor of Behavioural Intention (BI), and Behavioural Intention influences usage (Malatji, Eck & Zuva,

2020). TAM was first developed by Davis (1989), based on the theory of reasoned action (TRA) in psychology research to explain the acceptance of using technology (Masroom, 2007). TAM is a model related to technology adoption and focuses on the factors which influence a person's general computer acceptance (Ma & Liu, 2005; Masrom, 2007; Rauniar et al., 2014). TAM consists of two primary constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). PU is the extent to which a person believes that using a particular system will enhance their job performance (Sun et al., 2009; Lai, 2017).

In the context of this study, the researcher trained mathematics teachers in using Kahoot as a formative assessment technology in mathematics lessons. It was hoped that the teachers would find Kahoot a helpful technology and adopt it. PU is determined by the teachers' belief that Kahoot supports them in assessing their mathematics learners. On the other hand, PEU is the belief that using a particular technology will be easy (Hsu & Chang, 2013). For example, the study participants, who were teachers, adopted Kahoot as they found it easy to use in assessing students' knowledge and learning. TAM aligns well with Kahoot as an assessment technology in mathematics lessons because teachers who the researcher trained before the study were observed assessing the learners using Kahoot and found the tool (Kahoot) useful and hence accepted and used it. The TAM constructs PU and PEU coloured yellow in the above framework **(Figure 1)** are essential to the researcher in addressing the research problem. The complete concepts of TAM are External variables, Perceived usefulness, Perceived ease of use, Attitudes towards ICT, Intention to use and Actual use (Davis, 1989).

3.5.1 Perceived Usefulness (PU)

Perceived usefulness (PU) is the degree to which a person believes that using a particular system would enhance his or her job performance (Davis, 1989; Masrom et al., 2012; Hsu & Chang, 2013; Hassan, Kazmi & Padlee, 2019)**.** Perceived usefulness is an individual's perception that usage of a new system will help him or her achieve gains in their work performance (Cheema et al., 2013). Usefulness means being capable of being used in a helpful way (Davis, 1989). However, in the context of this study, the participants, primary school mathematics teachers, found the use of Kahoot as a formative assessment technology beneficial to the way they assess the learners. But it is imperative to note that technology adoption is not a panacea for instructional challenges. Teachers are diverse; some are techno-savvy, while others are techno-phobic. What causes people to accept or reject technology is determined by their PU. This means that people tend to use or not use an application to the extent they believe

it will help them perform their job better (Davis, 1989). Therefore, the participants' TK helped them assess learner content knowledge better.

3.5.2 Perceived Ease of Use (PEU)

Perceived ease of use (PEU) refers to how a person believes that using a particular system is easy (Davis, 1989; Masrom, 2007; Nair & Das, 2012; Hsu & Chang, 2013; Austermann & Mertins, 2014). Perceived ease of use is an individual's perception that it requires no cost or effort to adopt a new system or technology (Cheema et al., 2013). On this premise, an application perceived to be easier to use than another is more likely to be accepted by users (Davis, 1989). Deslonde and Becerra (2018) argue that individuals are more likely to accept and use new technology if they perceive it easy to use. PU and PEU are considered distinct factors influencing the user's attitude towards using the technology, though perceived ease of use is also hypothesised to influence perceived usefulness and attitude towards using the technology. Finally, such an attitude towards using the technology determines the behavioural intention to use that technology (Masrom, 2007). In general, teachers perceive that assessment is imperative in teaching and learning. Therefore, formative assessment comes with many challenges to teachers ranging from time on task and lesson planning to its implementation. The researcher was expected to train the mathematics teachers on the use of Kahoot as an assessment tool so that they beneficially use Kahoot.

3.5.3 Attitudes toward Technology Use (A)

TAM proposes that perceived ease of use and perceived usefulness of technology are predictors of user attitude towards using the technology (Masrom, 2007). In a similar discourse, Granić and Marangunić (2019) hypothesise that a user's attitude toward technology is a significant determinant of whether the user will use or reject the technology. User attitude plays an imperative factor when it comes to technology adoption. Guzman and Nussbaum (2009), as cited by Deslonde and Becerra (2018), argue that merely acquiring the hardware or software is insufficient to integrate technologies and stress the importance of the user's attitude. The more positive the user's attitude about technology, the higher the actual usage (Teo, 2011). Besides barriers such as limited training on new software, age of the user, bandwidth challenges, slow data access, time delays in downloading content, and limited equipment may impact a person's PU and PEU (Deslonde & Becerra, 2018; Hassan et al., 2019). To sum up, monitoring the mathematics teacher's attitude toward using Kahoot as an assessment technology in mathematics lessons assisted the researcher in gaining an insight into whether they were adopting or rejecting the new technology.

3.5.4 Behaviour Intention (BI)

According to Malatji, Eck and Zuva (2020), Behaviour Intention (BI) is a person's inspiration or intention to apply an effort to carry out the objective behaviour. The BI is the most crucial factor of Fishbein and Ajzen's (1975) theory of reasoned action, commonly used to forecast behavioural intentions and behaviours. According to the Theory of Reasoned Action (TRA), Behaviour Intentions are the pre-steps before an individual displays a specific behaviour. Therefore, BI influences a person's actions under the condition that the person assumes a relationship between the outcome and a definite behaviour (Liu et al., 2005; Austermann & Mertins, 2014). Behavioural intention positively and substantially affects actual behaviours (Lioa et al., 2018).

Furthermore, TRA asserts that beliefs influence attitudes, which lead to intentions and therefore generate behaviour (Kusumawati et al., 2019). Hassan et al. (2019) thus added that the model states that the behavioural intention to use of an individual is based upon two beliefs, namely perceived usefulness and perceived ease of use that both mediate the effects of external variables, such as system characteristics, development process, and training on intention to use. In addition, the model that Davis developed in 1989 is known as TAM version 1. TAM1 has been extensively criticised, despite being used by many researchers in the field of technology, education, and computer science. One criticism advanced by Revythi and Tselios (2019) suggests that TAM does not consider factors such as age and education as external variables which could influence acceptance of and willingness to use technology. Another limitation is that behaviour cannot be reliably quantified in an empirical investigation, owing to many different subjective factors such as the norms and values of societies and personal attributes and personality traits (Ajibade, 2018), thus the development of TAM version 2.

3.6 Technology Acceptance Model 2

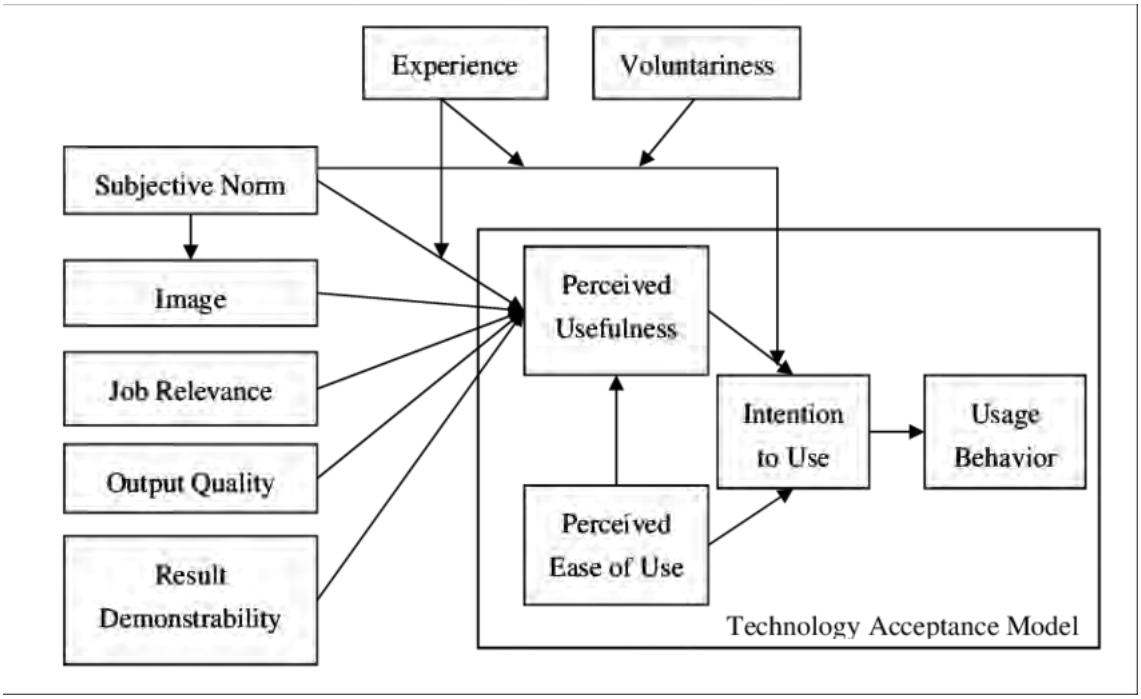
Using TAM as the starting point, TAM2 incorporates additional theoretical constructs spanning social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use) (Venkatesh & Davis, 2000). TAM2, an extension of the TAM, was developed due to the limitations of the TAM in terms of explanatory power. The goal for the TAM2 was to keep the original TAM constructs intact, include additional key determinants of TAM's perceived usefulness and usage intention constructs, and understand how the effect of these

determinants changed with increasing user experience over time with the target system (Nikolopoulos & Likothanassis, 2018). TAM went through numerous changes. For example, an upgraded model named TAM2 erased the attitude (ATT) variable from the model, which initially arbitrated some of the effects of PU and PEU. TAM2 also included a variable meant to capture the social influence that forces end-users to assess positively and accept information technology, named subjective norm (SN) (Malatji et al., 2020). TAM has been extensively criticised, even with its numerous utilises. TAM's critical comments as a hypothesis contain incomplete descriptive and analytical power and lack practical value (Zaineldeen, Hongbo & Hassan, 2020). Thus, in 2000, Venkatesh and Davis expanded TAM to clarify perceived usefulness factors. The expanded model, known as the TAM2, contains social influence processing variables (subjective norms, image, as well as voluntariness), cognitive instrumental processing variables (perceived ease of use, result demonstrability, output quality, job relevance) (Zaineldeen et al., 2020).

Table 1: The Constructs of Perceived Usefulness in the TAM2 adapted from Zaineldeen, Hongbo and Hassan (2020)

Constructs	**Definition**
Subjective Norm	The extent to which a person feels that individuals suppose he or she has to carry out the behaviour
Image	It can be characterised as the degree to which one's status is viewed to be improved by the employment of innovation in one's status of social systems
Job Relevance	The level to which the innovation is correlated to the job of someone
Results Demonstrability	is distinct as visibility of results
Output Quality	Distinct as "to what extent the novel technology executes work made by the user."

Figure 3: The TAM2 adapted from Venkatesh and Davis (2000)



Many studies identified limitations of TAM2; therefore, in 2008, it was modified from TAM2 to TAM3. The TAM2 is criticised as a non-complete model because it does not determine the factors that impact the perceived ease of use (Miller, 2019; Schmoll, 2019; Zaineldeen et al., 2020). Below is an in-depth discussion of TAM3:

3.7 Technology Acceptance Model 3

Venkatesh and Bala (2008) updated the Technology Acceptance Model from version two to TAM3, focusing on expanding the number of determinants that affect Perceived Usefulness and Perceived Ease of Use of innovation. In that way, they produced a positive Behavioral Intention followed by Use Behavior. Factors that influence Perceived Usefulness are Subjective Norm, Image, Job Relevance, Output Quality, and Result Demonstrability (Izuagbe & Popoola, 2017). Perceived Ease of Use is influenced by anchor variables (Computer Self-Efficacy, Perceptions of External Control, Computer Anxiety, and Computer Playfulness) and adjustment variables (Perceived Enjoyment and Objective Usability). Experience and Voluntariness act as modifiers of Behavioral Intention (Jeffrey, 2015). Because TAM2 only focused on the determinants of TAM's perceived usefulness and usage intention constructs, TAM3 by Venkatesh and Bala (2008) added the determinants of TAM's perceived ease of use and usage intention constructs for robustness. Therefore, TAM3 presented a complete

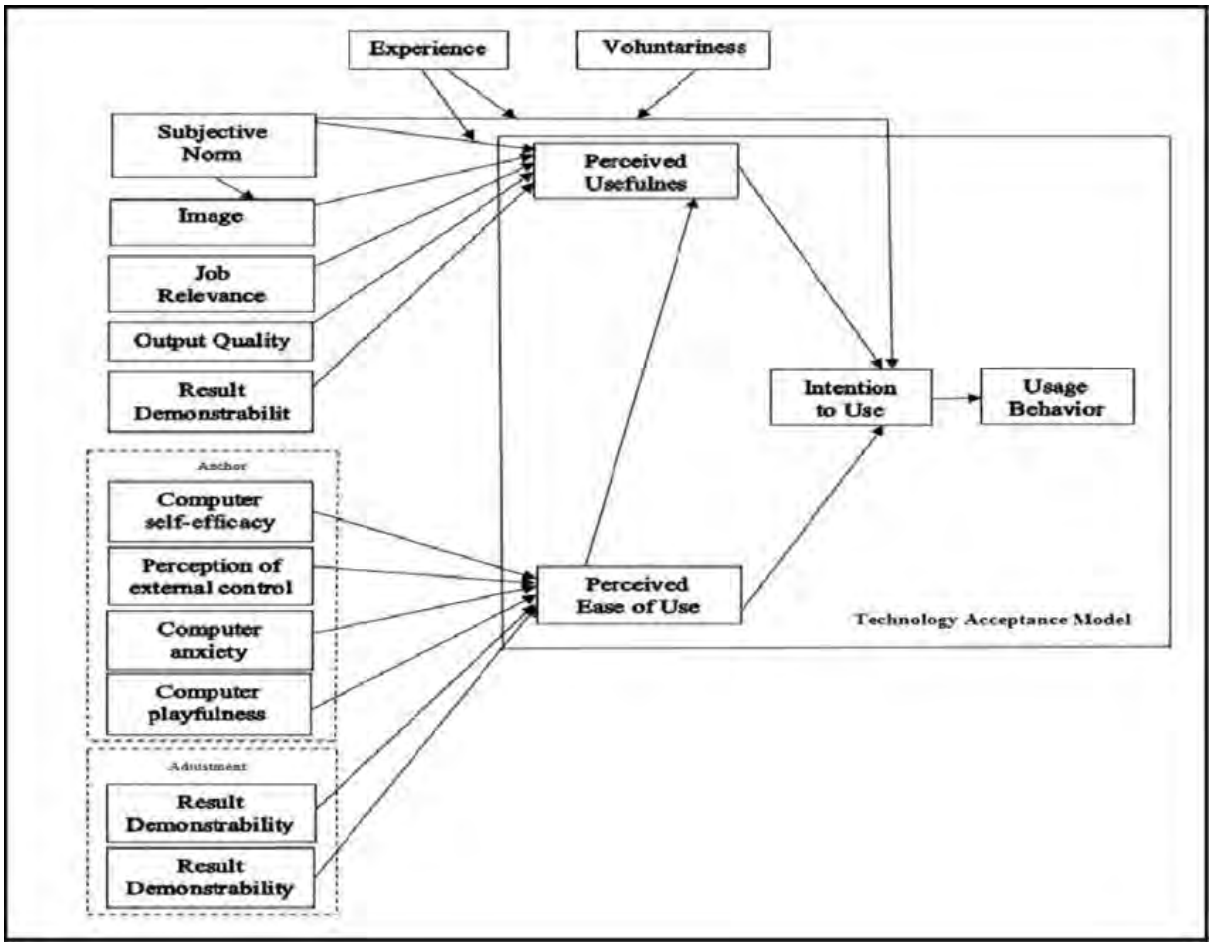
nomological network of the determinants that predict user information technology adoption (Nikolopoulos & Likothanassis, 2018).

Many studies have identified limitations of TAM2 to address the connection between technology and the actual adoption and use of technology. The TAM2 may be criticised as being a non-complete model because it does not determine the factors that impact the perceived ease of use and is insufficient to explain users' adoption and use of new technology (DUtot, 2015; Ahmad, 2018; Ajibade, 2018; Yu et al., 2018) thus the generation of TAM3. Venkatesh and Bala (2008) combined TAM2 (Venkatesh & Davis, 2000) and the model of the determinants of perceived ease of use (Venkatesh, 2000) and developed an integrated model of technology acceptance known as TAM3 (Lai, 2017). TAM3 offers a combined model with significance assigned to perceived usefulness and perceived ease of use so that it can address how managers and people who make decisions can make informed decisions regarding technology interventions (Malatji et al., 2020). TAM3 is an extremely long and complicated model. The researcher is aware of the criticism and revisions of the model; however, TAM1 developed by Davis (1989) has been adopted in this study because it aligns well with the context and purpose of the study. Below is a brief discussion of the constructs of TAM3.

Table 2: The Constructs of Perceived Ease of Use in the TAM3 adapted from Zaineldeen, Hongbo and Hassan (2020)

Constructs	Definition
Computer Anxiety	The concern about utilising the computer or concern of the potential of operating a computer
Perceived enjoyment	The level to which "the activity of applying a particular framework is considered interesting in its own right, regardless of the consequences."
Computer self-efficacy	The level to which persons believe they can achieve a particular work utilising the computer
Computer playfulness	The fundamental inspiration to cooperate with the new framework
Objective Usability	The technology-based comparison regarding the actual, instead of user perception, effort that is compulsory to achieve a specific task
Perception of external control	The level to which a person supposes that organisational assets are obtainable to ease the system use

Figure 4: The TAM3 adapted from Venkatesh and Bala (2008)



3.8 Analytical framework

An analytical framework explains the methods through which the author derived the related results (Hussain, 2017). Theory can be an interpretive tool. For some researchers, the decision as to which theory or theories will inform the final interpretations of the data is a choice that can only be finalised during the data collection and analysis cycles. The researcher held many theories in mind when designing the study and engaging in data collection (Varpio et al., 2020). Thus, in this study's context, Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework is the relevant theory to interpret the study findings. As seen before, the TPACK framework is made up of seven constructs: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK) and Technological Pedagogical Content Knowledge (TPACK). But for this study, two constructs: TK and TPCK, were used to interpret the generated data for research

questions two and three. For research question one, the researcher used the two constructs of the TAM: PU and PEU. The researcher was interested in how primary school mathematics teachers use technology in general and Kahoot, in particular, to check for conceptual understanding in the learners.

3.9 Rationale for using TPACK over other frameworks

There is a plethora of ICT integration models that have been developed over the years, such as Gladhart's (2001) Apple Classrooms of Tomorrow (ACOT); Puentedura's (2006) Substitution Augmentation Modification and Redefinition (SAMR), Koehler and Mishra's (2006) Technological Pedagogical Content Knowledge (TPACK), Garrison, Anderson and Archer's (2000) Community of Inquiry (COI), and Pedagogical Social Technological affordances (PST). The researcher evaluated some of these models and selected TPACK as a theoretical framework because it aligns well with the study objective and unit of analysis. The TPACK framework enables thinking about the complex problems that occur when digital technology is integrated into teachers' work practice (Mishra & Koehler, 2008; Salavati, 2016). TPACK serves as a useful conceptual framework for thinking, analysing, and evaluating what teachers must know to integrate technology into teaching. But ultimately, it must be understood as a framework for how teachers might best develop this integrated knowledge (Baran, Chuang & Thompson, 2011; Schmidt-Crawford & Jin, 2018). It is a theoretical framework for understanding teacher knowledge required for effective technology integration (Mishra & Koehler, 2006). Also, TPACK acts as a helpful framework for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge (Baran et al., 2011).

In addition, the TPACK framework offers several possibilities for promoting research in teacher education, teacher professional development, and teachers' use of technology. It has provided options for looking at a complex phenomenon like technology integration in ways that are now amenable to analysis and development. Moreover, it has allowed teachers, researchers, and teacher educators to move beyond oversimplified approaches that treat technology as an "add-on" to focus instead, and in a more ecological way, upon the connections among technology, content, and pedagogy as they play out in classroom contexts. Many researchers anticipate much more work in this area (Koehler, Mishra & Cain, 2013; Taopan, Drajati & Sumardi, 2020). Thus, on this premise, the researcher adopted TPACK as a theoretical framework for the study. Though the researcher adopted the TPACK framework,

there is a plethora of ICT integration models that have been formulated over the years. Below is a discussion of two models: the Apple Classrooms of Tomorrow (ACOT); and the Substitution, Augmentation, Modification, and Redefinition (SAMR).

3.9.1 The ACOT model

The Apple Classrooms of Tomorrow (ACOT) projects were conducted over ten years to investigate what happens to students and teachers when they have access to technology whenever they need it (Saepuloh & Salsabila, 2020). ACOT is an innovative framework that uses the 'level of adoption' of technology integration to help teachers identify their level of education technology skills (Johari, Azli & Idrus, 2018). The ACOT integration model covers teachers' typical application, attitudes, and behaviours in teacher ICT integration, among other ICT adoption models. This model explains teachers' ICT integration in five consecutive stages; entry, adoption, adaptation, appropriation and invention (Acun & Karabulut, 2011). These developmental stages denote a continuum of how teachers effectively use technology to aid the teaching and learning process, with the entry stage as the nethermost level and the invention stage as the pinnacle of technology deployment (Kurniawati, Maolida, Anjaniputra, 2018). The ACOT model comprises five stages: entry, adoption, adaptation, appropriation and invention.

In the *entry stage*, teachers are not comfortable with technology. They avoid using it, and they rely on others for technical support. They also do not make explicit connections between computer work and the rest of the curriculum (Brooks-Young, 2010). This means that the teacher heavily relies on the traditional methods of instruction. In a similar discourse, the entry stage constitutes teachers' knowledge of technology, in which teachers are coping with how to use the technology (ACOT, 1996; Muir-Herzig, 2004; Brooks-Young, 2010). At this stage, teachers are uncertain about technology that could be employed in their classrooms. According to Rein (2000), the entry-level teachers are signified by their withdrawal from using digital media and fear of students' use of technology. He affirms that this results from their concern about technology as an unmanageable tool. The teachers tend to use direct instructions and traditional methods to present students' materials (Kurniawati, Maolida & Anjaniputra, 2018).

The *adoption stage* is where teachers use new technology to support traditional instruction (Johari, Azli & Idrus, 2018). For example, they learn the basics of using new technology (Saepuloh & Salsabila, 2020). Acun and Karabult (2011) argued that teachers use ICT to improve their productivity when doing traditional tasks in the adoption stage. This stage is also characterised by teachers' use of one or two software applications they find helpful for

themselves, little student use of computers in the classroom, and the Internet used by the teacher for lesson planning (ACOT, 1996; Brooks-Young, 2010). In the third stage, *adaptation,* technology is used to enrich the curriculum. Teachers begin to use ICT to enhance it in ways connected to the curriculum (Acun & Karabult, 2011). For example, teachers integrate new technology into traditional classroom practice (Johari, Azli & Idrus, 2018). They often focus on increased student productivity and engagement using word processors, spreadsheets, and graphics tools (Saepuloh & Salsabila, 2020). This is the transition stage where teachers begin using technology with their students (ACOT, 1996; Brooks-Young, 2010).

The next stage is *appropriation,* where real change begins to take place. Teachers consider teaching objectives, the best approach, and the best tools. More relaxed classroom management gives students more responsibility. Student tasks are more rigorous, open-ended and multidisciplinary (ACOT, 1996; Brooks-Young, 2010). Schoepp (2004) further commented that teachers focus on cooperative, project-based, and interdisciplinary work-incorporating the technology as needed and as one of many tools. Then the final stage is *invention,* where teachers discover new use of technology tools, for example, designing projects that combine multiple technologies (Johari, Azli & Idrus, 2018). At this stage, teachers are ready to develop technology for several functions in the classroom, such as creating projects through the combination of multiple technologies (ACOT, 1996; Brooks-Young, 2010; Kurniawati, Maolida & Anjaniputra, 2018). Furthermore, as can be seen from the ACOT model discussion, teachers are the key figures in this model (Acun & Karabulut, 2011). The SAMR framework is another technology integration model to be discussed.

3.9.2 The SAMR framework

Ruben R. Puentedura developed the SAMR model in 2006 as part of his work with the Maine Learning Technologies Initiative (Puentedura, 2006). The model was intended to encourage educators to significantly enhance the quality of education provided via technology in the state of Maine. The SAMR model consists of four classifications of technology used for learning activities: substitution, augmentation, modification, and redefinition (Romrell, Kidder & Wood, 2014). The SAMR model intends to describe and categorise teachers' use of digital technology in classrooms (Salavati, 2016).

In the first stage, *substitution*, the technology provides a substitute for other learning activities without functional change (Puentedura, 2013). This entails the replacement of a hardcopy test with a digital version. For example, students write using a digital tool—such as Google Docs—

instead of paper and pencil. The second stage, *augmentation*, is about utilising technology to improve (Tsybulsky & Levin, 2016). The technology provides a substitute for other learning activities but with functional improvements (Romrell et al., 2014). For example, students may take a quiz using Google Classroom instead of pencil and paper or incorporate images, video, and sound into their slideshow. The third stage, *modification*, is about applying technology for significant task redesign (Puentedura, 2013). This is the first step over the line between enhancing the traditional goings-on of the classroom and transforming the classroom through the use of computer technology (Puentedura, 2009). For instance, students use audio and video or animation to create a video presentation. In the final stage, *redefinition*, technology allows for the creation of tasks that could not have been done without using the technology (Salavati, 2016). For example, students may publish their writing on a blog or learning management system. Furthermore, teaching activities within the substitution and augmentation classifications enhance learning, while learning activities within the modification and redefinition classifications transform learning (Puentedura, 2013).

The main criticism of the SAMR model, according to Hamilton, Rosenberg and Akcaoglu (2016), concerns lack of context, rigid structure and focus on the technological product overuse process. SAMR does not include context, which according to Hamilton et al. (2016), is essential to consider for any model referring to teaching and learning. The teachers' learning, pedagogy, practice, and students' learning experiences are contextual, so including context enables addressing multifaceted, complex educational settings (Salavati, 2016). SAMR ignores the complexity of technology use and defines and categorises teachers' use of digital technologies in predefined ways (Salavati, 2016). Although Puentedura developed the SAMR model to encourage the use of technology generally, Hockly (2013) suggested using the SAMR model specifically for mobile learning within the context of English language teaching (Romrell et al., 2014). Due to the criticism of the SAMR model by different academics, it was eliminated for this study because it does not align directly with the study objective, which is exploring how primary school mathematics teachers use Kahoot as a formative assessment tool.

3.10 Limitations for using the TPACK framework

Although the researcher adopted TPACK as a theoretical and analytical framework for this study, the researcher is fully aware of the criticisms and limitations of using this theory. For

example, no technology is a panacea for education (Knolton, 2014). Thus the seminal work of Cox and Graham (2012) caution that the framework is not yet fully understood. While Mishra, Koehler, and others have provided definitions of TCK, TPK, and TPACK that articulate the centres of these constructs, the boundaries between them are still quite fuzzy, thus making it challenging to categorise borderline cases (Cox & Graham, 2012). The TPACK framework has been criticised by several authors (Cox & Graham, 2009; Archambaud & Barnett, 2010; Graham, 2011) who state lack of context, exclusion of the relationship between students and teachers, differences between grade levels as well as guides and paths on how to acquire TPACK, as the main shortcomings. In a recent publication, Rosenberg and Koehler (2015) address some criticism of the TPACK framework, stating that context is essential and has been included in the framework. For example, the context is illustrated as a dashed circle (Salavati, 2016). The TPACK framework falls short when adding technology in the classroom; it does not provide a clear roadmap on how teachers should integrate technology in the classroom as learners and teaching contexts vary. Another significant limitation of the TPACK framework is that teachers are diverse; their content, pedagogical, and technological knowledge are not the same.

3.11 Chapter summary

This chapter discussed Davis' (1989) Technology Acceptance Model (TAM) as well as Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) as theories that underpinned this study. The chapter also presented the TPACK-In-Action model, which guided the workshop's design. The concepts and theoretical framework of TAM and TPACK served as a guide for the workshop's design. Concepts from the TPACK framework, particularly Technological Knowledge (TK) and Technological Pedagogical Content Knowledge (TPCK), informed this study's data analysis. The discussion was extended to the ICT integration models developed over the years, such as ACOT and SAMR frameworks. Lastly, the limitations of the TPACK framework were reviewed. The next chapter presents the research design and methodologies used in the study.

CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The previous chapter focused on the discussion of the theoretical framework underpinning this study, and that was the combination of Davis' (1989) Technology Acceptance Model (TAM) together with Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework. This chapter, therefore, focuses on the research design and methodology. Research design is the overall plan for addressing a research question, including specifications for enhancing the study's integrity (Polit & Beck, 2012). Research methodology is the specific procedures or techniques used to identify, select, process, and analyse information about a topic (Kothari, 2004). This chapter begins by presenting the three types of research methods: quantitative, qualitative and mixed methods, then justifying the adoption of the mixed methods research design and interpretive research paradigm, which the researcher employed in the study. Next, the chapter presents the use of a case study as the research style. The discussion is then extended to the research site, participants and sampling. Data generation techniques and data analysis; methods employed in this study are outlined. Analysis is the organisation and synthesis of data to answer the research questions and test the hypotheses (Polit & Beck, 2012). Data analysis is making sense of the data (Dix, 2020). The researcher then explains strategies used to enhance the study's trustworthiness to ensure that the results obtained are plausible. Lastly, ethical considerations pertaining to this study are outlined.

4.2 Research orientation

To gather the data that responded to the research questions, the interpretive paradigm underpinned the study. A paradigm is thus a comprehensive belief system, worldview, or framework that guides research and practice in a field (Lincoln & Guba, 2000; Taylor & Medina, 2011). It represents a worldview that defines, for its holder, the nature of the 'world,' the individual's place in it, and the range of possible relationships to that world and its parts (Lincoln & Guba, 1994). Therefore, the purpose of the interpretivist is to develop a great understanding of how people make sense of the contexts in which they live and work (Bertram & Christiansen, 2014). In this study, the researcher adopted the tenets of the interpretive paradigm because it offered him an opportunity to interact and understand the actions of the participants as he was immersed in the study for over three months. The interpretive paradigm

was suitable for understanding the research problem since the study sought the participants' perceptions regarding the use of Kahoot as a formative assessment technology in mathematics lessons. But the limitation of the interpretive paradigm noted by the researcher was that it does not change the thinking and beliefs of the participants but accepts their viewpoints on how they use Kahoot for formative assessment. Also, what the researcher found on the ten primary school mathematics teachers (participants) about how they use Kahoot as a formative assessment technology cannot be generalised to the entire population of Swaziland primary school mathematics teachers because the participants were a single case and chosen using purposive sampling. Furthermore, the study's research design was underpinned by Saunders et al. (2015) Research Onion as illustrated in Figure 5 below.

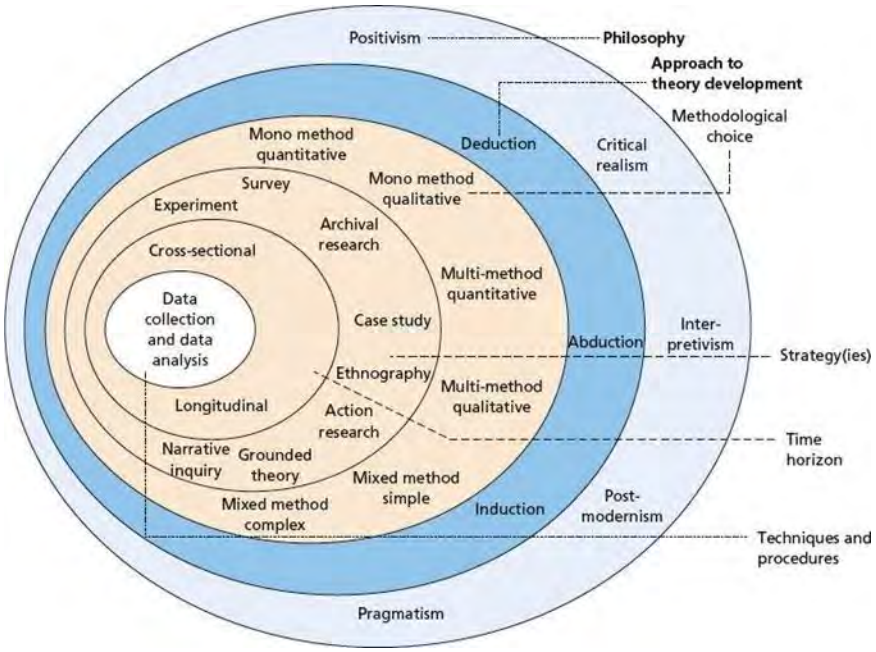


Figure 5: The Research Onion
Source: Adapted from Saunders et al. (2015)

4.3 Research method

The research method is the overall approach used to generate the data needed to respond to the research questions and therefore achieve the study aims. The method used in the research will differ from one study to another, depending on the type of research. For example, scientific research will introduce scientific experiments to reveal the results that need to be analysed. On the other hand, other methods such as surveys, case studies, observations, and interviews are

also used for scientific or social research. However, when the research employs more than one type of method, it is then called mixed methods, and this method is widely used today in social research (Fetters, Curry & Creswell, 2013). This research adopted an exploratory research design and collected quantitative and qualitative data from ten primary school mathematics teachers. Therefore, the researcher decided to employ mixed methods for the current study. Both qualitative and quantitative approaches are joined to triangulate the results from data collected that help understand the problem rather than using a single approach (Creswell & Clark Plano, 2011). According to Creswell et al. (2013), there are three types of research methods: quantitative, qualitative and mixed methods.

4.3.1 The quantitative research method

Quantitative research is a mode of inquiry used for deductive research when the goal is to test theories or hypotheses, gather descriptive information, or examine relationships among variables (Antwi & Hamza, 2015). Creswell (1994) has given a very concise definition of quantitative research as a type of research that explains phenomena by collecting numerical data analysed using mathematically based methods, particularly statistics. Leedy and Ormrod (2019) argue that quantitative research is specific in its surveying and experimentation, as it builds upon existing theories. The quantitative research methodology maintains the assumption of an empiricist paradigm (Creswell, 2003). The research itself is independent of the researcher. As a result, data is used to measure reality objectively. Quantitative research creates meaning through objectivity uncovered in the collected data.

Quantitative research relies on deductive reasoning or deduction (Cramer-Petersen et al., 2019). It uses various quantitative analysis techniques that range from providing a simple description of the variables involved to establishing statistical relationships among variables through complex statistical modelling (Mertler, Vannatta & LaVenia, 2021). Quantitative research calls for typical research designs where research focuses on describing, explaining and predicting phenomena, using probability sampling, and relying on larger sample sizes compared to qualitative research designs (Sim et al., 2018). By using particular methodologies and techniques, quantitative research quantifies relationships between different variables. In quantitative research involving two variables, for example, the researcher aims to study the relationship between an independent (predictor) variable and a dependent (criterion) variable in a population (Mohajan, 2020). In this research, the researcher used the quantitative method

to gather quantitative data, which were analysed statistically to answer research question one. The quantitative methodology obtained accurate and reliable measurements that allowed a statistical analysis. For example, the researcher used structured questionnaires to gather quantitative data about the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology. These quantitative data sets were statistically analysed and compared to the qualitative results to understand the research problem better. The researcher found that analysing and interpreting quantitative data was not easy. Participants provided numerical descriptions rather than detailed narratives. Therefore, it was difficult for the researcher to analyse and interpret the participants' PEU and PU of Kahoot since responses were numbers; thus, assistance from quantitative research experts was sought. In this study, data were also gathered using the qualitative method.

4.3.2 The qualitative research method

Qualitative research typically focuses on narrative data and analyses (Graff, 2017). One identifier of qualitative research is the social phenomenon being investigated from the participant's viewpoint (Williams, 2007). Qualitative research uses inductive reasoning in comparison to quantitative research (Williams & Moser, 2019). It aims to acquire an in-depth understanding of human behaviour and the reasons for the occurrence of that behaviour. Qualitative research can also be called interpretive research as its primary objective is not generalisation but to provide a profound interpretation of the phenomena (Hays & McKibben, 2021). It is used in many academic disciplines such as social sciences; and market research (Denzin & Lincoln, 2005), particularly where the objective is to probe human behaviours and personalities. Given the unique purposes of qualitative research, it adopts typical research designs, uses non-probability sampling, and relies on smaller samples (Williams & Moser, 2019). It also uses different data collection and analysis techniques than quantitative research (Clark & Vealé, 2018).

Furthermore, there are five types of qualitative research: case study, ethnography study, phenomenological study, grounded theory study, and content analysis. These five types represent research built upon inductive reasoning, which is, drawing a conclusion from a set of specific observations (Williams, 2007). In this study, the qualitative methods were used to develop a level of detail from high involvement in the actual experiences as the researcher was exposed to the natural setting (Creswell, 1994). The study used observations, focus group

interviews, workshops, and journal reflections to gather qualitative data about the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology. These qualitative data sets were thematically analysed and compared to the quantitative results to understand the research problem better. Furthermore, the quantitative data analysis was underpinned by TAM, while TPACK underpinned qualitative data. The researcher found that analysing and interpreting bulky quantitative data is time-consuming. This study collected qualitative and quantitative data concurrently, thus the adoption of the mixed methods research design.

4.3.3 Mixed methods research design

Research designs are plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis (Creswell, 2009). It involves the intersection of philosophical assumptions, strategies of inquiry, and specific methods. A research design is a master plan specifying the methods and procedure for collecting and analysing the needed information (Akhtar, 2016). There is no single blueprint for planning research. The notion of fitness governs research design. This study aimed to determine the methodology and design of the research (Cohen et al., 2007). According to Creswell (2009), there are three types of research designs: qualitative, quantitative, and mixed methods. Quantitative researchers focus on numeric data and analyses; qualitative researchers typically focus on narrative data; mixed methods researchers focus on numerical and narrative data analyses (Graff, 2017). Quantitative data is numerical data analysed using statistics (Muijs, 2004), whereas qualitative data refers to data that can either be textual or visual (Creswell & Plano Clark, 2007; Graff, 2017). The study follows a mixed methods approach which is largely qualitative with a thin quantitative strand.

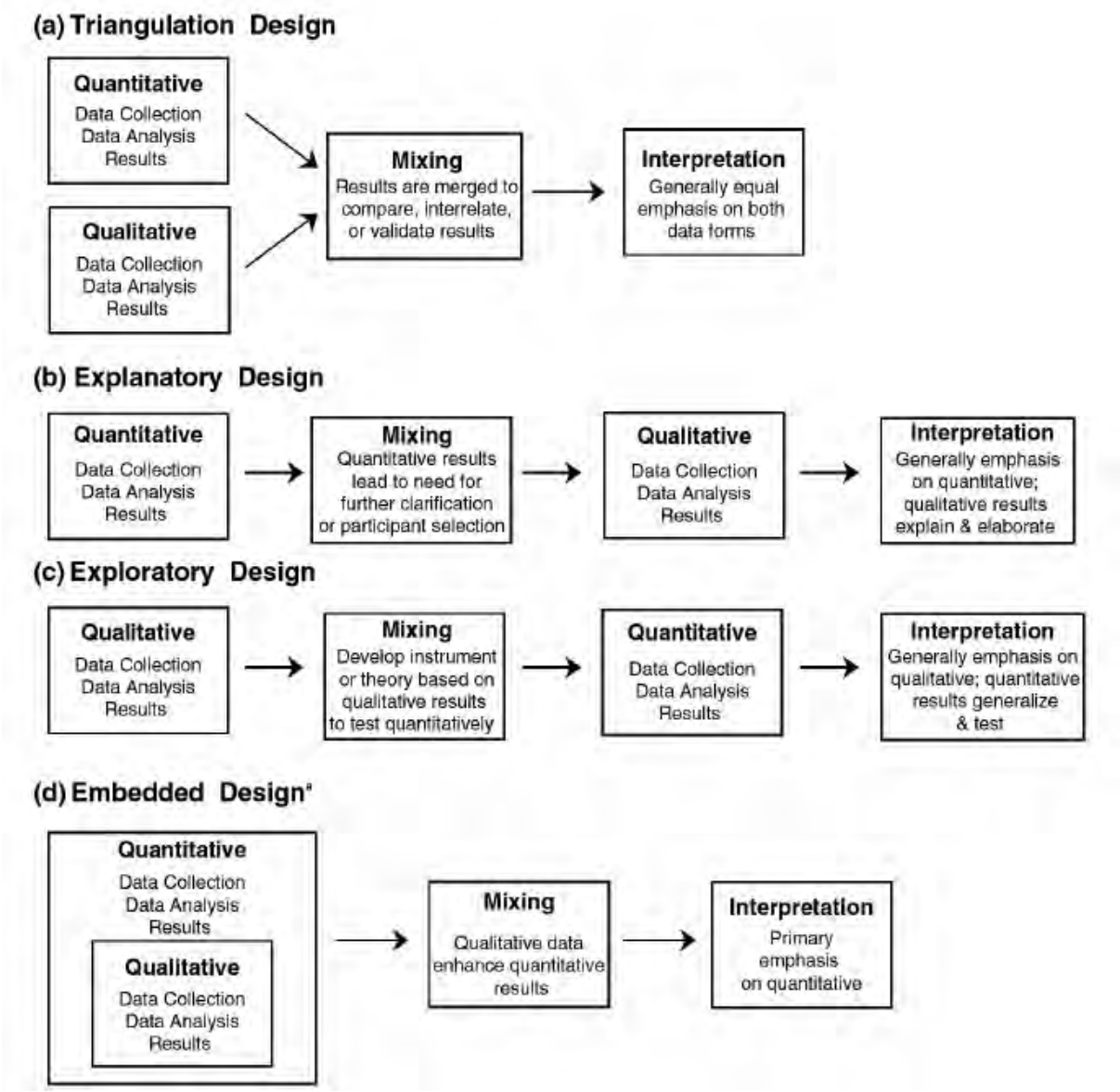
Mixed methods research is the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, as well as inference techniques) for the general purposes of breadth and depth of understanding (Creswell, 2009; Schoonenboom & Johnson, 2017). Mixed methods is defined as research in which the investigator collects and analyses data, integrates the findings and draws inferences using qualitative and quantitative approaches in a single study (Creswell, 2007; Doyle, Brady & Byrne, 2009). This form of research is more than simply collecting quantitative and qualitative data. It indicates that data will be integrated, related, or mixed at some stage of the research process (Creswell, 2004) or used in tandem so that the overall strength of a study is greater than either qualitative or

quantitative research (Creswell & Plano Clark, 2007). Therefore, mixing means that the qualitative and quantitative data are merged on one end of the continuum, kept separate on the other end of the continuum, or combined between these two extremes (Creswell, 2009). However, the term mixing is misleading, as the components are not simply mixed but have to be integrated very carefully. Morse and Niehaus (2009) identify two possible points of integration: the results point of integration and the analytical point of integration. Similarly, the overall goal of mixed methods research of combining qualitative and quantitative research components is to expand and strengthen a study's conclusions (Schoonenboom & Johnson, 2017). There are four major types of mixed methods designs: the Triangulation Design, the Embedded Design, the Exploratory Design, and the Explanatory Design (Creswell, 2006). The researcher collected quantitative data using structured questionnaires and qualitative data using focus group interviews, journal reflections, workshops, and observations at the same time. Also, the data were analysed separately, and results were merged to compare and interrelate the results. In the interpretation stage, the researcher used the qualitative data to explain the quantitative data to understand the research problem better. Thus, the study adopted the triangulation design.

The most common and well-known approach to mixed methods is the Triangulation Design. In a concurrent triangulation approach, the researcher collects both quantitative and qualitative data concurrently and then compares the two databases to determine if there is convergence (Creswell, 2009). The researcher collected different but complementary data (quantitative and qualitative data) at the same time to understand how primary school mathematics teachers make use of Kahoot as a formative assessment technology. The TAM was used to analyse and interpret the participants' perceptions of Kahoot usefulness and ease of use (quantitative data). The researcher used the concepts of TPACK: TK and TPCK to analyse and interpret the participants' enabling and constraining factors of using Kahoot as an assessment technology, and how they make use of Kahoot as an assessment technology (qualitative data). The purpose of using this design was to bring together the differing strengths and non-overlapping weaknesses of quantitative methods with those of qualitative methods (Creswell, 2006). Triangulation or greater validity refers to the traditional view that quantitative and qualitative research might be combined to triangulate findings so that they may be mutually corroborated (Schoonenboom & Johnson, 2017). In this study, the integration of qualitative and quantitative data sets occurred during the interpretation phase. The researcher found that using mixed

methods provided more substantial evidence for the study findings. Figure 6 below summarises the four main typologies of mixed methods research design.

Figure 6: Summary of the four main typologies of mixed methods research design



Source: Adapted from Creswell & Plano Clark (2007)

4.3.3.1 Advantages of using mixed methods

The goal for researchers using the mixed methods approach to research is to draw from the strengths and minimise the weaknesses of the quantitative and qualitative research approaches (Johnson & Onwuegbuzie, 2004). Using TAM and the TPACK framework concurrently to

analyse and interpret data assisted the researcher in enhancing the study's trustworthiness and integrity of the research findings; hence the credibility of the study improved. For example, explaining quantitative results with qualitative results assisted the researcher in developing a comprehensive understanding of how the participants use Kahoot as a formative assessment technology. Bangi (2018) argues that a mixed methods approach counter-acts weakness and enables corroboration of the qualitative and quantitative methods through triangulation. The researcher found that mixed methods research offers a practical approach to addressing the research problem and the possibility for increased applicability because the problem was scrutinised in different ways. Furthermore, using the triangulation design was effective because quantitative and qualitative data were collected simultaneously, thus offering the researcher an opportunity to understand the research problem in different ways. The researcher also noted that during the study, he could return to the qualitative data and reread quotes to understand better the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology (quantitative results). For instance, if all the participants select "Strongly Agree" on the Likert scale questionnaire, the researcher can go back to the gathered interview data to investigate "why". Creswell et al. (2011) concur that mixed methods intentionally integrate or combine these methods to draw on the strengths of each other. Although it is clear that a mixed methods approach has much to offer a researcher, there have been criticisms of its use.

4.3.3.2 Limitations of using mixed methods

Many of these criticisms focus on the incompatibility thesis, that is, the belief that quantitative and qualitative research methods cannot be mixed in a single study as they have different ontological and epistemological origins (Creswell, 2007; Doyle et al., 2009). The researcher found that conducting mixed methods research is not easy. It took time for the researcher to analyse and interpret the quantitative and qualitative data sets. For example, when the quantitative and qualitative methods were merged, the results were contradictory; thus, mixed methods experts assisted the researcher in analysing and interpreting the collected data. Another limitation was that qualitative and quantitative phases were undertaken concurrently; therefore, it required more expertise from the researcher in data analysis and interpretation. Within a mixed methods study, there is also a requirement that the researcher has at least a sufficient knowledge of both quantitative and qualitative methods independently and then mix these methods appropriately to achieve good study results.

4.4 Case study

A case study is a research approach used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context (Rule & John, 2011; Crowe et al., 2014). A holistic inquiry investigates a contemporary phenomenon within its natural setting (Harling, 2012). A case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in real life (Simons, 2009). Case studies are a qualitative strategy in which the researcher explores a programme, event, activity, process, or one or more individuals in depth. The case(s) are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period (Creswell, 2009). A case study is a general term for the exploration of an individual, group or phenomenon (Rebolj, 2013). A case study explores a real-time phenomenon within its naturally occurring context, considering that context will create a difference (Rashid, 2019). It is useful where the question is "How?" or "Why?" (Treloar et al., 2017). Furthermore, there are several types of case studies. Yin (2009) identifies three such types in terms of their outcomes: exploratory (as a pilot to other studies or research questions), descriptive (providing narrative accounts); explanatory (testing theories).

Moreover, the case in this study was ten primary school mathematics teachers. A case study was appropriate because it aligned with the interpretive paradigm, and it can also be used to generate claims for further verification (Bertram & Christiansen, 2014). Furthermore, the unit of analysis, therefore, was the primary school mathematics teacher's use of Kahoot as a formative assessment technology in mathematics lessons; their perceptions and experiences of using Kahoot as a formative assessment technology and the enabling and constraining factors of using Kahoot as a formative assessment technology in mathematics lessons.

In this study, a case study was appropriate since the researcher explored how primary school mathematics teachers use Kahoot as a formative assessment tool. It was a comprehensive description of the participants in their natural settings. The strength of using a case study was that it supported the researcher in gaining a holistic view of a particular phenomenon or series of events and provided a round picture since many sources of evidence were used (Rashid et al., 2019). Furthermore, the case study methodology enabled the researcher to explore complex phenomena within the selected school and teachers involved in-depth. Creswell (2007) argued that a case study is a good approach when the inquirer has clearly identifiable cases with boundaries and seeks to provide an in-depth understanding of the cases or a comparison of several cases.

However, in adopting a case study in this study, the researcher noticed some limitations of this research style. One of the challenges inherent in case study development was that the researcher must identify his or her case. Selecting the case required the researcher to establish a rationale for his or her purposeful sampling strategy for selecting the case and gathering information about the case ***(see, section 4.5.3).*** Again, a case study contains a bias towards verification, that is, a tendency to confirm the researcher's preconceived notions, and it cannot provide reliable information about the broader class (Nardi, 2018). The researcher found that studying more than one case weakens the overall analysis; the more cases an individual studies, the less the depth in any single case.

4.5 Research site and participants

4.5.1 Research site

The research was conducted at Central Academy (pseudonym), a rural primary school in Swaziland in the Shiselweni region. The school has a population of one thousand learners (1 000) and thirty-five (35) teachers. The school was officially opened in 1990. Over the years, it has increased the number of learners and acquired technologies to support teaching and learning, such as a computer laboratory and library. The Shiselweni region is situated in the southern part of Swaziland, a country bordered by Mozambique and South Africa. Additionally, the number of participants was ten (10) primary school mathematics teachers. Figure 7 represents a map of Swaziland that shows the location of the region and the place where the research was carried out.

Figure 7: Political map of Swaziland
Source: mapsofworld.com

The Shiselweni region where the study was conducted

4.5.2 Selection of the site

The research adopted the case study, and as such, it is important to note that case studies can be either single or multiple-case designs. Single cases confirm or challenge a theory or represent a unique or extreme case (Hoorani et al., 2019). Single-case studies are also ideal for revelatory cases where an observer may have access to a previously inaccessible phenomenon. These designs require careful investigation to avoid misrepresentation and maximise the investigator's access to the evidence (Hunziker & Blankenagel, 2021). The researcher must consider whether to study a single case or multiple cases. The study of more than one case dilutes the overall analysis; the more cases an individual studies, the less the depth in any single

case. Selecting the case requires that the researcher establish a rationale for his or her purposeful sampling strategy for selecting the case and for gathering information about the case (Creswell, 2007). Thus the researcher selected a site where he works. This site was chosen for its convenience and its suitability to meet the following criteria: located within the proximity of the researcher; teachers do have access to ICT devices such as laptops and mobile phones; the school has access to internet connectivity for teachers and learners; there is a computer laboratory. In addition, Crowe (2014) argues that the selected case study site(s) should allow the research team access to the group of individuals, the organisation, the processes or whatever constitutes the chosen unit of analysis for the study. The researcher selected a single case to study. This allowed him more time for an in-depth study of the participants.

4.5.3 Selection of participants

In this study, the participants were chosen using purposive sampling. In purposive sampling, researchers handpick the cases to be included in the sample based on their judgement of their typicality or possession of the particular characteristic being sought (Cohen et al., 2018). The researcher selected primary school teachers because of their mathematical content knowledge and experience in relation to the study. In the context of this study, the sample was all ten (10) mathematics teachers in the school. Due to the COVID-19 pandemic, participants followed the COVID-19 rules and guidelines to contain the pandemic's spread: regular washing of hands, face mask-wearing, and two-metre social distancing. Then when presenting the research findings, the researcher used the data of the teachers who agreed to be part of the study and attended all the workshops conducted by the researcher.

The selection of cases should mostly depend upon the research problem (Rebolj, 2013). This study seeks to address the gap in knowledge that most mathematics assessments in primary schools ask learners to memorise facts instead of understanding mathematical concepts and processes. Thus the case, primary school mathematics teachers, was selected not because it was representative of other cases but because of its uniqueness, which was of genuine interest to the researcher (Crowe, 2014). The researcher made a participant selection criteria. All the teachers had to meet the selection criteria below to participate in the study:

i. Must have been a qualified primary school mathematics teacher,
ii. Must have five years or more of teaching mathematics,
iii. Must have web navigation skills, and
iv. Must be knowledgeable about typing words on a computer.

The researcher purposely selected all the ten (10) mathematics teachers in the school to be the study case. Thus, Crowe et al. (2014) suggest that each case should have a pre-defined boundary which clarifies the nature and time covered by the case study (i.e. its scope, beginning and end), the relevant social group, organisation or geographical area of interest to the investigator, the types of evidence to be collected, and the priorities for data collection and analysis. The following table contains the background information of the participants.

Table 3: Background information of mathematics teachers

Teacher Pseudonym	Grade	Age	Gender	Academic qualifications	Number of years teaching mathematics
Jabu	1	43	Female	PTD	10
Glenda	2	38	Female	PTD	8
Lindiwe	3	32	Female	PTD	5
Jerry	4	30	Male	BED	6
Josh	5	34	Male	PTD	7
Winston	6	29	Male	BED	6
Olivia	7	35	Female	BED	7
Jack	5	30	Male	PTD	5
Nomuzi	6	33	Female	PTD	5
Victor	7	28	Male	PTD	5

4.6 Research instruments

To respond to the research questions, the researcher employed the followed data generating methods: workshops, observations, structured questionnaires, focus group interviews as well as journal reflections. Methods refer to the range of approaches used in educational research to gather data to be used as a basis for inference and interpretation, explanation and prediction (Cohen et al., 2018). Research methods involve data collection, analysis, and interpretation that researchers propose for their studies (Creswell, 2009). The researcher used different instruments so that they complement the weaknesses of each other. Each of these data-generating methods are discussed below:

4.6.1 Workshops

A workshop means an arrangement whereby a group of people learn, acquire new knowledge, perform creative problem-solving, or innovate concerning a domain-specific issue (Ørngreen & Levinsen, 2017). Thus, in this study's context, the participants were trained on the use of Kahoot as a formative assessment tool. Workshops foster engagement, a crucial element for their success, through collaborative discussions and constructive feedback between the participants and the workshop facilitator (Lain, 2017). The purpose of the workshop in this case study was to collect narratives from primary school mathematics teachers to interrogate their perceptions on the use of Kahoot as a formative assessment technology. It also allowed the participants to share their different levels of experience and expertise in using technology at the beginning of the workshop (Treloar et al., 2017).

The workshops were conducted at Central Academy (pseudonym of the research site) and attended by all the participants. This study had two workshops which adhered to COVID-19 protocols of screening by checking body temperatures of the researcher and participants as they entered the venue, compulsory wearing of masks, sanitisation and sitting arrangements that allowed for social distancing in the workshop venue (Jandrić et al., 2020). As discussed in the theoretical framework section, the TPACK-in-Action model proposes that a workshop follows these five steps: a) Modeling; b) Analysing; c) Demonstrating; d) Application; and e) Reflection. The first four steps were conducted in the first workshop, and the last step, reflection, was done in the second workshop. The first workshop was conducted before the study started. It was used to gather data on the teachers' views and attitudes on Kahoot use for assessment in general. The researcher also introduced the purpose of the study and trained teachers on using Kahoot as a formative assessment technology in the classroom. The second workshop was conducted after the teachers had used Kahoot technology in their lessons to assess the learners' grasp of the mathematical concepts in the classroom situation. It was used to review the participants' experiences on using Kahoot as a formative assessment technology. Data generated during the workshops responded to the second and third research questions.

Though workshops are used in Education research to collect data, some scholars have noted strengths linked to them. Ahmed and Asraf (2018) suggest in their seminal work that through workshops, researchers may be able to elicit rich information from the participants who are selected through the purposive sampling technique. In the same manner, workshops accommodate the writing of thick and rick descriptions of field notes or rather "workshop notes", which can serve the purpose of transferability (Lincoln & Guba, 1985). This means that

any other researcher can conduct a similar study using the same procedure, hence contributing to the credibility of the results (Ahmed & Asraf, 2018). In addition to credibility, in this study, it was observed that workshops provided the researcher and participants opportunities to collaborate in learning about the use of Kahoot as a formative assessment technology in mathematics lessons. This helped the researcher to gather data through the collaboratively shared experience. The researcher noted that the workshop facilitates participants' openness and creativity. For example, some participants copied existing Kahoot games from the Internet and adapted them to fit their needs. The researcher also noted that the participants gained a more confident and experimental attitude towards Kahoot as an assessment technology during the workshop. The workshop heightened the teacher' TK about Kahoot use in the classroom. In addition, some cases required the two workshops served as an avenue for the practice of mathematics teachers who are interested in using and integrating ICT in their practices.

The researcher was aware of some of the limitations of using workshops to generate data in research. He noted that conducting the two workshops required committed participants who promoted genuine participation. The participant group was kept small to allow everyone personal attention and the chance to be heard. The participants were expected to participate and influence the workshop's direction actively and practice the relevant techniques, skills, situations, and so forth. Though the workshop improved the participants' perceived usefulness (PU) on Kahoot use, guiding the workshop discussion needed the researcher's expertise to attain objective results. Some participants had difficulty grasping the technology knowledge (TK) of creating their Kahoots and were frustrated. Another limitation was the workshop set-up pushed some teachers into a hiding and passive position. Therefore, it was not easy for the researcher to get the views and experiences of unwilling participants. Also, the researcher found that participants who did not collaborate were not involved in the workshop discussion wholeheartedly and thus provided poor responses. He also noted that the workshop results were dependent on the researcher's clinical performance to create a good atmosphere, facilitate the sense of giving each participant space, and be sensitive to verbal and nonverbal communication. In addition to the reasons above, it may be hard for the researcher to fit everything he wants to cover into a single workshop. Data were also generated through observation.

4.6.2 Observation

Observation as a method of data collection in a qualitative study suggests that the researcher takes field notes on the behaviour and activities of individuals at the research site and records

observations (Creswell, 2009). Observation was used in this study to collect data by directly watching and recording participants' behaviours. There are two principal types of observation: participant observation and non-participant observation. Participant observation involves being in the setting under study as both observer and participant. Non-participant observation involves observing without interacting with the objects or people under study in the setting. The qualitative researcher may make observations either as a relative outsider or, especially in the case of an ethnography, as a participant-observer (Leedy & Ormord, 2019). In the context of this study, the researcher noted that being a participant observer is not easy to be objective. The collected data were the researcher's opinion; thus, another researcher may interpret it differently.

The primary advantage of conducting observation in this study was that the researcher could take advantage of unforeseen data sources as they surface (Leedy & Ormord, 2019). Moreover, the researcher noted that the use of observation guide offers data collection method for gaining insight into situations. The researcher did not rely on the opinions of others that he got from interviews or questionnaires. The research was conducted where the researcher works; thus, it was easy to gain trust and rapport with the participants. Therefore, the researcher got more data on the participants' TK when the learners were formatively assessed using Kahoot in the classroom. Khakimova (2019) asserts that observation can be used where it is impossible to collect data using interviews or questionnaires, such as when the study participants are animals, babies, young children, persons who do not share a common language, or persons with some forms of disability. The distinctive feature of observation as a research process was that it allowed the researcher to gather 'live' data from naturally occurring social situations. In this way, the researcher looked directly at what was happening in the research site rather than relying on secondary data.

There are also disadvantages to using observation. One main disadvantage noted by the researcher was that the researcher's presence affected the participants' behaviour; thus findings attained might be biased. For example, the participants may behave differently if an observer is in the classroom. Also, the researcher noted that it was impossible to observe everything. A non-participant observer is detached from the situation and relies on the participants' perception, which may be inaccurate. At the same time, there is a possible lack of objectivity in the participant-observer (Kabir, 2016). Though most of the teachers demonstrated an enriched TPCK when using Kahoot to assess the learners, it was impossible to generalise the findings from observations to another context as the sample was small and chosen using

purposive sampling. Another limitation noted by the researcher was that he was in complete control over data he felt was worthy of being gathered. This might have led to research bias. The researcher used an observation schedule sheet ***(see, Appendix 5)*** with pre-set questions.

The researcher conducted ten observations for the selected mathematics teachers when assessing learners using Kahoot for those who agreed to be part of the study. The observation focused mainly on how the participants designed their Kahoots to support formative assessment. Observation allowed the researcher to gather authentic data from the participants' natural context. The generated data were used to answer research questions two and three. Being an insider researcher, the researcher had an opportunity to view things from the participants' perspective hence understanding the problem better as he interacted with the participants in their natural setting. The researcher found it difficult not to adopt the group's values, norms, and behaviours as he was a participant-observer and a teacher in the school where the study was conducted. This means that when the researcher ceases to be a researcher and becomes a group member, he loses objectivity. In this study, data were also generated through structured questionnaires.

4.6.3 Structured questionnaires

Questionnaires are printed sets of field questions to which participants respond on their own (self-administered) or in the researcher's presence. They can thus be administered through the post, electronically, or face-to-face (Rule & John, 2011). The questionnaire is a well-structured technique within social science research for acquiring information on participants' social characteristics, present and past behaviour, standards of behaviour or attitudes and their beliefs and reasons for action concerning the topic under investigation (Bird, 2009). Although there is a range of questionnaires, there is a simple rule of thumb: the larger the size of the sample, the more structured, closed and numerical the questionnaire may have to be, and the smaller the size of the sample, the less structured, more open and word-based the questionnaire may be (Cohen et al., 2018). The researcher noted that keeping the questionnaire short and using simple, straightforward, unambiguous language make the respondents cooperative. Bird (2009) concurs that to generate data conducive to the research goals, questionnaire format, sequence and wording, the inclusion of classification, behavioural, knowledge and perception questions, and questionnaire length and output need to be considered to ensure reliability, validity and sustained participant engagement.

There are mainly two types of questionnaires: closed-ended (structured questionnaire) and open-ended (unstructured questionnaire). Open questions offer less structured response options than closed questions, inviting respondents to recount understandings, experiences, and opinions in their style. Closed questions, on the contrary, may seek quantitative information about respondent attributes (for example, level of educational attainment) or behaviour, for example, how often and where respondents buy groceries (McGuirk & O'Neill, 2016). In open-ended, for instance, respondents answer in their own words, while in closed-ended, they select one or more options from a predetermined set of responses (Ahmad, 2013). To add to that, Cohen et al. (2018) caution that an open-ended question is a very attractive device for smaller-scale research or for those sections of a questionnaire that invite an honest, personal comment from respondents in addition to ticking numbers and boxes. The researcher noted that the appearance of the questionnaire is vitally important. It must look easy, attractive and interesting rather than complicated, unclear, forbidding and boring. Therefore, the researcher used a structured questionnaire to generate quantitative data to allow statistical analysis in this study.

A structured questionnaire asks more closed-ended questions. Closed questions prescribe the range of responses from which the respondent may choose. Highly structured, closed questions are helpful because they can generate response frequencies amenable to statistical treatment and analysis. They also enable comparisons across groups in the sample (Cohen et al., 2018). The researcher found that they are quicker to complete and more accessible to code. Responses can be presented as simple yes/no choices, multiple tick boxes or subjects may be invited to rank choices by order of preference or complete a Likert scale (Williams, 2003). Open-ended questions allow the respondents freedom to answer a question in their own words in whichever way they think appropriate (Bertram & Christiansen, 2014). The questionnaires ***(see, Appendix 6)*** were self-administered after the participants attended the workshop that offered the pedagogical and technological experiences of using Kahoot as a formative assessment technology. They were used to gather data that responded to the first research question: What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology? The questionnaire was used to gather data on the teachers' perception of the usefulness and ease of using Kahoot in mathematics formative assessment. Therefore, the researcher explained the purpose of the questionnaire to the respondents and requested them to answer all the questions. Also, the researcher expressed to participants on voluntary responding to the questionnaire, and participants were allowed not to respond to questions they felt were uncomfortable. The researcher piloted the questionnaire with two teachers of the same

school where this study was carried out. This exercise helped the researcher check the clarity of the questionnaire items, instructions and layout; to eliminate ambiguities in wording; and gain feedback on the attractiveness and appearance of the questionnaire (Cohen et al., 2018). The researcher used a Likert scale to assess the perceptions and attitudes of primary school mathematics teachers on using Kahoot as a formative assessment technology. The participants responded to 11 questions about the usefulness of Kakoot and nine questions about Kahoot's ease of use. The answers were divided into five different levels of expression: Strongly Agree, Agree, Neither agree nor disagree, Disagree and Strongly Disagree. Each of the responses had a numerical value used to measure the perception and attitude of participants. This allowed the quantitative data to be analysed quantitatively (using tables and bar graphs). The participants were given one day to respond to the questionnaires after gaining the technological experience of using Kahoot to assess the learners.

The researcher noticed numerous strengths of using structured questionnaires as a data generation instrument in research. The questionnaires were returned in a short time, which was one day. The researcher noted that structured questionnaires reduce the amount of thinking that a respondent needs to undertake to complete it as participants' responses were presented as multiple tick boxes. Therefore, all the structured questionnaires given to the participants were returned to the researcher. The researcher also noted that collecting data using questionnaires is cheaper and more versatile. Structured questionnaires allowed the researcher to gauge the participants' responses toward the PU and PEU of Kahoot statistically. The quantitative results were compared to the qualitative results, and this enhanced the study's credibility. Yoo and Rho (2021) maintain that questionnaires are the cheapest way of gathering information from hundreds or thousands of people in extensive scale surveys. The researcher also noticed that questionnaires helped gather original data about participants, their behaviour, experiences and social interactions, attitudes and opinions, and awareness of events. For instance, the structured questionnaires were used to gather the participants' perceptions of Kahoot's usefulness and Kahoot ease of use. Questionnaires are flexible – can be used with other data collection methods to allow for an in-depth understanding of the research problem. Furthermore, the researcher found it easy for the participants to fill in the structured questionnaires as the questions were simple and predetermined by the researcher.

The researcher also noticed limitations of using a structured questionnaire as a data generation tool. The participants did not ask the researcher to explain misunderstood questions. Thus they wrote dishonest answers. Also, the researcher noticed that using English words that are difficult

when formulating the questionnaire leads to invalid study findings. The researcher was not present to clarify misunderstood questions when the respondents answered the questionnaires in this study. The respondents selected predetermined questions on the questionnaire, which allowed for statistical analysis of the data. But the researcher did not get the honest attitudes and perceptions of the participants on Kahoot's ease of use and Kahoot usefulness, as the participants might have responded to questions without careful consideration. Data were also generated through a focus group interview.

4.6.4 Focus group interview

The researcher used a focus group interview to get more data for triangulation. A focus group interview (FGI) is an in-depth field method that brings together a small homogeneous group (usually six to twelve persons) to discuss topics on a study agenda (Kabir, 2016). The researcher used FGI to collect data because it aims to collect high-quality data in a social context (Pham, 2018), which primarily helps understand the research problem from the participants' viewpoint (Dilshad & Latif, 2013). The FGI was used in this study to gather qualitative data. The focus was on understanding the experiences and challenges the teachers (participants) encountered when using Kahoot as a formative assessment technology in mathematics lessons. The researcher created a space that offered participants to share their views and the technological and pedagogical experiences they encountered when using Kahoot to assess the learners formatively. He then initiated interview questions that all participants answered and tape-recorded the responses. He further engaged all ten participants in a discussion about their experiences on using Kahoot as a formative assessment technology in mathematics lessons. There were five males and five females in the focus group interview that was held in the computer laboratory for twenty-two minutes. Also, the researcher requested participants to consent to the recording of the FGI. Rule and John (2011) assert that focus group interviews are helpful in gaining a sense of the range and diversity of views. But Brent and Kraska (2021) argue that group interviews may experience the pressure toward conformity and that individuals may be stifled rather than stimulated by the group. In this study, the researcher noted that the person speaking in a FGI experienced a lot of interruptions from the participants in such a way that others were afraid to raise an opposing idea.

The researcher identified several strengths of using focus group interviews to gather data in this study. The FGI was beneficial for gaining a sense of the range and diversity of views in a short space of time and the gathered data resulting from the interaction among the participants. Dilshad and Latif (2013) concur that rich qualitative data can be collected reasonably since

focus group sessions require only a moderate time commitment from participants and moderators. Also, the interaction helped the researcher to notice how and why the primary school mathematics teachers think about the use of Kahoot for formative assessment of mathematics. Therefore, the researcher collected qualitative data with reasonable speed. The FGI helped the researcher identify agreements and disagreements among the participants regarding their TK and TPCK of using Kahoot as a formative assessment technology in mathematics lessons. Though a focus group interview is one of the valuable tools for collecting qualitative data, it has some limitations.

The researcher experienced some limitations associated with focus group interviews to gather data. The quality of the generated data depended on the researcher's experience in facilitating discussion among the primary school mathematics teachers. For example, the researcher sometimes dealt with conflict among the participants, encouraged passive participants to talk, and created a welcoming environment so that everybody would be free to speak. Another limitation experienced by the researcher was that the extrovert participants dominated the discussion; thus, the presence of excessively loud participants in the focus group interview subdued the views of the shy participants. Therefore, the participants got unequal speaking times. Sim and Waterfield (2019) corroborated this idea by stating that the discussion is likely to be dominated by extroverts, a small coalition of participants. The researcher also noted that the interaction among ten participants forced some participants to conform to the responses of other vocal counterparts, even though they may disagree. Another limitation experienced by the researcher while calming conflicts among the participants was that crucial points which were to be expressed by a particular participant were not heard for the benefit of a collective view. It is important to note that the focus group data were used for triangulation purposes to enhance the credibility of the study and it contributed to the other data sets. Data were also generated through journal reflections.

4.6.5 Journal reflections

Reflective journals have been used widely in teacher education programs to promote reflection on teacher practices (Clarke, 2004; Göker, 2016). Reflective journals comprise a vital part of documenting the practice of different professions, such as nursing, and in fields such as musical education, business administration, psychology, and education (Bashan & Holsblat, 2017). One method that has the potential for collecting qualitative data has been through reflection. Reflective journaling means describing a recent experience and unpacking salient aspects that affected learning and doing so in an ongoing manner over time (Lutz & Paretti, 2019). Journal

writing is a way of getting feedback from ourselves (Janesick, 1999). The ten participants reflected on the use of Kahoot as a formative assessment technology each day they used Kahoot in mathematics lessons. The researcher designed a reflecting guide ***(see, Appendix 8)*** using predetermined questions so that the data gathered will be thematically analysed. He also reflected on the entire research process in a journal to document the needed contextual information about the study. The participants spent about ten minutes completing the reflection exercise.

The researcher noted many benefits of using reflective journals to gather data in this study. Journal writing assisted the researcher in refining ideas and his responses to the research in progress. Also, the journals served as a self-assessment tool for the researcher in evaluating the participants' experiences with using Kahoot as a formative assessment technology. This idea is corroborated by Lindroth (2015), who asserts that journals can provide an opportunity for participants to create a dialogue with themselves. Journal writing captured data that the other methods did not offer, thus enhancing the study's trustworthiness. Another strength of journal writing noted by the researcher was that it allowed the participants to look back on their experiences and gain a conscious stance about their experiences of using Kahoot for formative assessment in mathematics lessons. Also, the researcher noted that reflection allowed the participants to realise the relationship between theory and practice. While the advantages of journaling have been noted for educational purposes, it has some limitations.

The researcher experienced some limitations in using journal reflections to gather data in this study. As reflection is a thinking activity that takes place after the act, the participants (teachers) could not remember everything that happened in the lesson when the learners were being formatively assessed using Kahoot but only small fragments of what happened. The participants reflected on the use of Kahoot in their formative assessment practices each day they used Kahoot. Some participants did not write their responses with consideration but wrote for the purpose of finishing the reflecting activity. Lutz and Paretti (2019) maintain that reflection is a cognitive activity, so it was imperative for the participants not to rush when writing their journals so that they could remember every detail. Furthermore, data generated from journal reflections were used to answer research questions two and three.

4.7 Data analysis

Data analysis is the process of making sense of the data (Merriam, 1999). Similarly, data analysis focuses on in-depth, context-specific, rich, subjective data and meanings by the

participants in the situation, with the researcher herself/himself as a principal research instrument (Cohen et al., 2018). The goal of involving the data analysis stage in the study was: (a) to look for patterns emerging from the raw data (b) and to judge if change will occur after the intervention (Leedy & Ormord, 2019). This study analysed data quantitatively and qualitatively, as illustrated in figure 8.

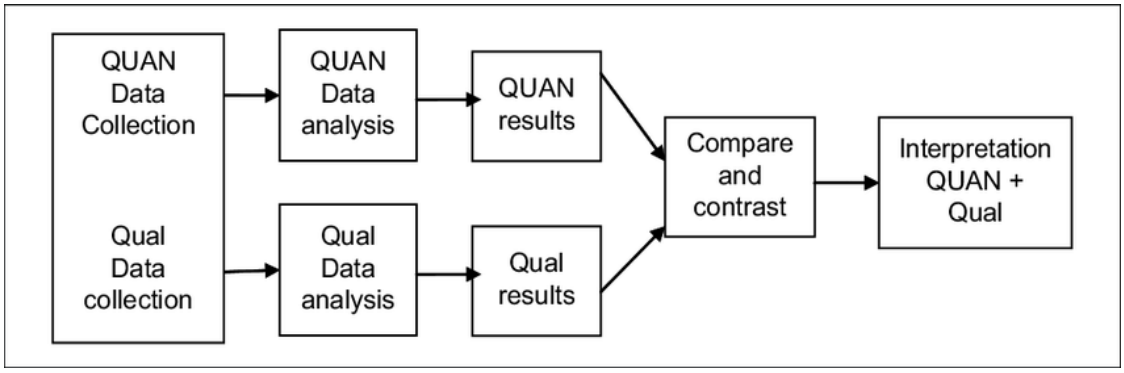


Figure 8: Triangulation Design

Source: Adapted from Creswell and Plano Clark, 2007

Data analysis is the systematic organisation and synthesis of research data and, in quantitative studies, the testing of hypotheses using those data. In the same manner, quantitative analysis is the manipulation of numeric data through statistical procedures to describe phenomena or assess the magnitude and reliability of relationships among them. In addition, data analysis is preceded by data cleaning. Data cleaning is preparing data for analysis by performing checks to ensure that the data are consistent and accurate (Pallant, 2020). On the other hand, qualitative analysis is the organisation and interpretation of narrative data to discover critical underlying themes, categories, and patterns of relationships (Kiger & Varpio, 2020).

The TAM and TPACK constructs, PU; PEU, TK and TPCK (discussed previously in the theoretical framework section) underpinned the data analysis. The research included the workshop that introduced primary mathematics teachers to using Kahoot as a formative assessment technology and then observed them while assessing the learners using Kahoot. The researcher conducted focus group interviews and used their reflective journals to make sense of the raw data regarding the teachers' TK, which was used to see if they designed the content for assessing the learners effortlessly (Creswell, 2009). That is, how the teachers created their Kahoots to support mathematics assessment in class. These data sets were analysed inductively.

The combination of TAM and TPACK constructs enabled the researcher to see additional emerging themes that were not visible.

Table 4: Data presentation and analysis

Quantitative analysis		**Qualitative analysis**	
Descriptive analysis	TAM construct	Thematic analysis	TPACK construct
	PU, PEU		TK, TPCK

Data were collected from a structured questionnaire and analysed quantitatively using descriptive statistics at the end of the exploratory study to respond to the first research question. Descriptive statistic transform or summarises a set of data into either a visual overview such as a table or graph or into a single or a few numbers that summarise the data (Bertram & Christiansen, 2014). Data were recorded and grouped into different categories according to the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment tool. This data was then compared statistically, thus placing the researcher in a better position to understand the mathematics teachers' perceptions concerning assessing learners using technology in mathematics lessons.

For research questions two and three, data were collected from observations, workshops, reflective journals, and focus group interviews and analysed qualitatively through coding, categorising, and developing themes. Coding is transforming raw data into a standardised form for data processing and analysis. In quantitative research, it is the process of attaching numbers to categories; in qualitative research, it is the process of identifying and indexing recurring words, themes, or concepts within the data (Polit & Beck, 2012). In a similar discourse, it is the process of organising the material into chunks or segments of text to develop a general meaning of each segment (Creswell, 2009). A theme is a recurring regularity emerging from an analysis of qualitative data (Polit & Beck, 2012). However, the data analysis focused on primary school mathematics teachers' perceptions of using Kahoot as a formative assessment technology, their enabling and constraining factors of using Kahoot as a formative assessment technology, and the use of Kahoot as an assessment technology. The different data sets were coded and assigned to different categories so that the researcher could look for similarities and differences to generate themes from the raw data. The collected data were analysed using the TPACK framework constructs TK and TPCK based on the research questions that guided the study. Additionally, using different coloured pens and highlighters was vital at this stage to

categorise the raw data. Lastly, the researcher experienced challenges during data analysis and interpretation; the qualitative and quantitative findings were conflicting and contradictory.

4.8 Data triangulation

Triangulation refers to using multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena (Abdalla et al., 2018). It is the use of more than one particular approach when doing research to get richer, fuller data and or to help confirm the research results (Wilson, 2014). According to Moon (2019), triangulation is a strategy for increasing the validity of evaluation and research findings. In this study, data triangulation resulted in the researcher gaining a broader understanding of how primary school mathematics teachers use Kahoot as a formative assessment technology. The triangulation methods' effectiveness relies on the premise that the weakness of one gathering method will be compensated by the other counterbalancing strength of the other method (Hameed, 2020). Thus, triangulation in this study aimed to decrease, negate, or counterbalance the deficiency of a single strategy, thereby increasing the ability to interpret the findings (Natow, 2020). Though, there was the possibility that each method could target a different aspect of the underlying phenomenon leading to results that are complementary to each other. Morgan (2019) argues that comparing the results from multiple methods would help the study minimise the chance that the weaknesses of any single method might produce invalid conclusions.

There are four types of triangulation. Firstly, there is data source triangulation which is the use of different sources of data. For instance, the researcher simultaneously gathered qualitative and quantitative data and then compared the two databases to determine if there was convergence, differences, or some combination. This includes different times for data collection, different places to collect the data, and different people who could be involved in the research study (Fusch, Fusch & Ness, 2018; Jentoft & Olsen, 2019). Secondly, there is investigator triangulation which is using several people (or at least more than one) in the data gathering and analysis processes (Lemon & Hayes, 2020). In the context of this study, the data were analysed by the researcher with the assistance of mixed methods experts. Thirdly, there is theory triangulation which is approaching the data with multiple theories or perspectives in mind to extend the possibilities for producing knowledge (Flick, 2018). The researcher used TAM and TPACK to analyse and interpret data in this study. The researcher noted that different theories helped support or refute findings with theory triangulation. Fourthly, there is

methodological triangulation. The researcher used more than one method to gather data. These methods included: structured questionnaires, focus group interviews, journal reflections, observations and workshops.

In 2011, Guion, Diehl and McDonald introduced the fifth typology of data triangulation named environmental triangulation. This type of triangulation involves using different locations, settings, and other critical factors related to the study's environment, such as the time, day, or season. The key is identifying which environmental factors might influence the information received during the study. These environmental factors are changed to see if the findings differ across settings. The validity has been established if the findings remain the same under varying environmental conditions. The researcher collected data from different teachers who teach different grades to enhance environmental triangulation in this study. Furthermore, the participants had different content and pedagogical experiences of using Kahoot to assess learner conceptual understanding. The discussion shifts to the research evaluation.

4.9 Research evaluation

Trustworthiness or truth value of qualitative research and transparency of the conduct of the study is crucial to the usefulness and integrity of the findings (Cope, 2014). As a science in qualitative research, trustworthiness has been delineated by Lincoln and Guba (1985) within four criteria – credibility, transferability, dependability, and confirmability. The strategies are intertwined and interdependent and serve as alternatives to the conventional, quantitative measures for quality, such as internal validity, external validity, reliability, and objectivity (Lemon & Hayes, 2020). The study used a mixed-methods approach which is largely qualitative with a thin quantitative strand; thus, it uses Lincoln and Guba's (1985) suggestion to establish trustworthiness. The trustworthiness criterion in the Lincoln and Guba framework is discussed below:

4.9.1 Credibility

According to Rose and Johnson (2020), credibility deals with the question: How congruent are the findings with reality? Credibility refers to how the research represents the research participants' actual meanings or the truth value (Lincoln & Guba, 1985). In this study, the researcher used the quantitative and qualitative research approaches concurrently to enhance the integrity of the research findings. The confidence can be placed in the truth of the research findings. Credibility establishes whether the research findings represent plausible information

drawn from the participants' original data and correctly interpret the participants' original views (Korstjensa & Moser, 2018). In the context of this study, the researcher used multiple data collection methods to enhance its credibility. Also, the researcher took the gathered data to the study participants and asked if the interpretations were true; thus, external evaluation of the research process enhanced the study's credibility.

4.9.2 Dependability

The second criterion in the Lincoln and Guba framework is dependability, which refers to data stability over time and conditions (Polit & Beck, 2012). According to Cope (2014), dependability is the consistency of the data in a different context with a similar condition. The findings would be identical if another researcher repeated the study at Central Academy using a similar research design and participants, which were the primary school mathematics teachers. The researcher clearly documented the data collection methods ***(see, 4.6)*** and analysis ***(see, 4.7)*** used in the study. Also, the researcher was assisted by mixed-methods experts to analyse and present the gathered data, thus enhancing study dependability. Furthermore, the research process was logical and traceable. The researcher used the triangulation design, collected and analysed quantitative and qualitative data separately then compared the results. The third criterion in the Lincoln and Guba framework is transferability.

4.9.3 Transferability

According to Shenton (2004), transferability is concerned with how the findings of one study can be applied to other situations. This study collected quantitative and qualitative data sets. Mohamed (2017) argues that the researcher in naturalistic studies cannot anticipate the extent to which the study findings will be transferable to another context. In this study, it was difficult for the researcher to transfer the findings to other contexts because the researcher purposively selected a single case, a homogenous group of mathematics teachers in Central Academy. Instead, the researcher provided thick descriptions for those who want to transfer the findings to other contexts.

4.9.4 Confirmability

Confirmability is concerned with establishing that the researcher's interpretations and findings are clearly derived from the data, requiring the researcher to demonstrate how conclusions and interpretations have been reached (Nowell, 2017). Therefore, confirmability is the degree to which other researchers could confirm the research study's findings. It is concerned with establishing that data and interpretations of the findings are not figments of the inquirer's

imagination but clearly derived from the data (Korstjensa & Moser, 2018). In the context of the study, the researcher linked the results to the conclusions so that other researchers could repeat them. For instance, in research question one, the findings on teachers' perception of Kahoot use in formative assessment indicated to be positive because all the participants found Kahoot useful and easy to use. These findings were derived from the gathered data; most participants selected the option Strongly Agree in the Likert scale questionnaire pertaining to Kahoot's usefulness and ease of use. Similarly, the study findings were not figments of the researcher's imagination but clearly derived from the data. To develop trustworthiness in qualitative research, Lincoln and Guba (1985) initially presented four criteria: credibility, dependability, confirmability, and transferability. Responding to numerous criticisms and their own evolving conceptualisations, a fifth criterion, authenticity, which is more distinct within the constructivist paradigm, was added.

4.9.5 Authenticity

Authenticity refers to the ability and extent to which the researcher expresses the feelings and emotions of the participant's experiences in a faithful manner (Cope, 2014). It is how researchers fairly and faithfully show a range of realities (Polit & Beck, 2012). In this study, the researcher used journal reflections to gather data. Journal reflections assisted the researcher in capturing participants' personal voices, feelings and emotions pertaining to the use of Kahoot as a formative assessment technology in mathematics lessons. Therefore, the use of the participants' journal reflections enhanced the authenticity of the study. Furthermore, the researcher found that using the participants' quotes allowed the readers to grasp the essence of the participants' experiences. On the other hand, quantitative researchers' fundamental concerns are reliability, validity, generalisation, and objectivity.

4.9.6 Reliability

Reliability is an indicator of the stability of the measured values obtained in repeated measurements under the same circumstances using the same measuring instrument (Sürücü & MASLAKÇI, 2020). A highly reliable measure produces similar results under similar conditions, so, all things being equal, repeated testing should produce similar results. Hayes and Coutts (2020) observed that a reliable instrument has a small error or standard deviation. The researcher piloted the questionnaire with two teachers before the actual study commenced. In this study, Cronbach's alpha coefficient was utilised to estimate how consistently the

participants responded to the questions within the structured questionnaire. Below is the Cronbach's alpha formula:

$$\alpha = \left(\frac{k}{k-1}\right)\left(\frac{s_y^2 - \sum s_i^2}{s_y^2}\right)$$

Table 5: Cronbach's alpha for the study variables

Dimension	Number of items	Cronbach's Alpha
Usefulness	1-11	0.765
Ease of Use	12-20	0.823

According to **Table 5**, the Cronbach's Alpha was 0.765 for Kahoot Usefulness and 0.823 for Kahoot Ease of Use. The result obtained from the above teacher's questionnaires showed a value of more than 0.7 for all the items included, which was reasonable, indicating that the questionnaire was reliable for use in the study.

4.9.7 Validity of the research instrument

Validity is concerned with how an instrument measures what it is intended to measure. It has many aspects that complement each other; face, content, criterion, and construct (Waugh et al., 2021). To enhance content validity, the researcher consulted two experts to evaluate each expression in the structured questionnaire in terms of the content of the scale. The researcher noted that the participants might select an answer that may not reflect their true feelings in the structured questionnaire with pre-set answers. The research instrument was piloted, after which modifications were made to suit content validity of the instrument.

4.9.8 Generalisability

Generalisability is the extent to which the findings of a study can be applied to other settings (Degtiar & Rose, 2021). In this study, the participants were selected using purposive sampling. Therefore, the population is not representative of the entire population of primary school mathematics teachers in Swaziland. The findings can only be generalised to populations that share characteristics with the participants, such as Gender, Age, Grade, Academic qualification, and Number of years teaching mathematics.

4.9.9 Objectivity

Objectivity is the extent to which research projects are undistorted by the biases of researchers (John, 2021). Quantitative research method deals with quantifiable data and will, therefore, produce a more reliable result than qualitative research. The researcher presented and interpreted the quantitative data gathered from the structured questionnaires without contaminating it. The researcher remained distanced from what he researched, so findings depended on the nature of what was studied rather than on the researcher's personality, beliefs, and values.

4.10 Ethical considerations

Codes of ethics are ethical rules and principles drafted by professional associations that govern scholarly research in the disciplines (Creswell, 2009). Ethics are systems of moral values concerned with the degree to which research procedures adhere to professional, legal, and social obligations to study participants (Polit & Beck, 2012). The protection of human subjects by applying appropriate ethical principles is essential in any research study (Arifin, 2018). This study notes the importance of educational research in improving people's lives but strongly urges that the rights of participants be protected throughout the research process (Pillay, 2014). However, in terms of protecting the participant's right not to be injured or mistreated, it is normally the duty of the research team not to expose the research participant to significantly burdensome, unreasonable, known or predictable risks (Scott, 2012). The ethical approval was sought and granted from two main research ethics committees: the *Rhodes University Ethical Standards Committee* and the *Education Department Higher Degrees Committee* **(*see, Appendix 9, Ethics Clearance Letter*)**. Within certain disciplines, the social sciences, education, and medicine, human subjects in research is quite common. In this study, the researcher noted that ethics has to do with behaviour that is considered right or wrong.

4.10.1 Informed, voluntary consent

The cornerstone of ethical research is informed consent (Fleming & Zegwaard, 2018). An informed consent form is a written agreement signed by a study participant and a researcher concerning the terms and conditions of voluntary participation in a study (Arnott et al., 2020). This form acknowledges that participants' rights will be protected during data collection (Creswell, 2009). In this study, the researcher educated the participants about informed consent to choose whether to participate or not in the study. Before the study commenced, the researcher explained the expected benefits and risks of participating to the research

participants. Also, the researcher outlined the purpose of the study. Then the researcher explained foreseeable risks that might emanate from participating in the study to the participants and made them aware that they could withdraw from the study at any time without prejudice. To ensure that consent is informed and voluntary, the participant must have the capacity to both understand the information being provided regarding the particular piece of research and be free from coercion (Scott, 2012). This means that to participate in the study, the participants were adequately informed about the research, understood the information and had the power of freedom of choice to decide whether to participate or decline. Therefore, the researcher ensured that the participants gave informed, un-coerced consent by explaining the study's purpose, risks and benefits before it commenced. For instance, the participants were willing to be part of the study; and they were aware that the information provided would be used only for the study.

4.10.2 Gaining access

To gain access to the site for conducting research with the participants, the researcher needed to request "permission of access" from the gatekeepers of the school. In research, gatekeepers are individuals at research sites that provide access to the site and allow or permit a qualitative research study to be undertaken (Creswell, 2009). The first stage of engaging gatekeepers was gaining official permission to undertake research in the targeted school. This meant contacting an appropriate official or the school's principal in person or in writing. Before conducting this study, the researcher requested permission to undertake the study from the gatekeepers, who were the Swaziland Ministry of Education and Training and the school principal. The researcher explained the purpose and benefit of the study, informed consent; data generation methods; study time frame ***(see, Appendix 1 and 2)***. Furthermore, this study involved human participants, and therefore, human research ethics approval needed to be obtained. The researcher found that the participants were not afraid to participate in the study as permission was granted by the school principal.

4.10.3 Confidentiality

Confidentiality is another ethical rule import in research. The researcher ensured that the identity of participants was kept confidential or anonymous and avoided using self-identifying statements and information. Anonymity and confidentiality are essential steps in protecting the participants from potential harm (Fleming & Zegwaard, 2018). The researcher preserved the anonymity of the participants by not using their real names in the data collection, analysis and reporting of the study findings. Anonymity means that data cannot be linked to a specific

participant. With confidentiality, on the other hand, data can be separated from subjects' information, although the researcher can still link the data with an individual (Ketefein, 2015). As much as the participants have a right to privacy, to participate or not participate in the study, the researcher has a right to design, conduct and disseminate the research without interference.

4.10.4 Beneficence and non-maleficence

Two of the internationally accepted, fundamental core principles underpinning research are the principle of beneficence (do good) and the mirror principle of non-maleficence (do no harm) (Ketefian, 2015). The first premise for a researcher is to do no harm. The researcher needs to think about any adverse effects the study could have on any of the participants (Dooly, Moore & Vallejo, 2017). Thus the research benefited the participants. Participants gained the technological knowledge of using Kahoot as a formative assessment technology. Though participants were teachers in this study, learners (minors) were indirectly involved, so the researcher was aware of the importance of learners not being harmed in any way as a result of the research being conducted. The research participants gained expertise in using Kahoot as an assessment tool, leading to improved performance academically.

4.10.5 Justice

Justice has several meanings which include the meaning of retribution. Another meaning is justice as fairness. Questions that concern the research participants are: Who needs the benefits of the research the most? Who carries the heaviest burden? And who benefits the most? These are pertinent to justice as fairness (Ketefian, 2015). In this study, the participants were all the mathematics teachers of Central Academy (pseudonym) because this cohort possessed characteristics important to the researcher to address the research problem. In the context of research activity, the principle of justice can be conceptualised as fairness. Fairness is achieved if the principles guide the distribution of capabilities and resources. For example, these principles were applied to ensure that the least advantaged benefit and are not harmed or forgotten. Furthermore, the benefits and risks were fairly distributed across the study. In this study, the researcher applied the principle of equality concerning differences in participants' age, gender, and competence in using Kahoot as a formative assessment technology.

4.11 Chapter summary

This chapter focused on the research design and methodology. It began by stating and justifying the mixed methods research design and interpretive research paradigm in which this study is

located. Then it justified the use of a case study as the style of research. The discussion was then extended to the research site, participants and sampling. Data generation techniques and data analysis; methods employed in this study were outlined. The discussion was then extended to the strategies used to enhance the study's trustworthiness: credibility, dependability, transferability and confirmability. Lastly, ethical considerations pertaining to this study were outlined. The next chapter discusses the results and findings.

CHAPTER FIVE: RESULTS

5.1 Introduction

In the previous chapter, I presented the research design and methodology used to guide the activities involved in the study. The overarching objective of this study was to explore how primary school mathematics teachers make use of Kahoot as a formative assessment tool. This chapter is presented in two: in the first section, I discuss the findings from the first phase of data collection, the structured questionnaires that responded to the first research question, and the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology. The second section discusses data generated from observations, journal reflections, workshops, and focus group interviews on responding to the second and third research questions. The reader will be provided with the quantitative and thematic results by stating the emerging themes from the data. Research results are presented using both quantitative and qualitative methods to derive a variety of data capable of being triangulated. This effort has allowed the researcher to draw conclusions based on the findings and provide future researchers with suggestions for further research on this topic.

5.2 Research activities

The following is a summary of the research activities that the researcher undertook to conduct this study:

Phase 1: The researcher conducted two workshops with the ten selected primary school mathematics teachers (study participants) and adhered to COVID-19 protocols of screening by checking the body temperatures of the researcher and participants as they enter the venue, compulsory wearing of masks, sanitisation and sitting arrangements that allowed for social distancing in the workshop venue (Jandrić et al., 2020). In the first workshop, the researcher highlighted the study's rationale and explained all ethical issues pertaining to the study. Then the researcher introduced the use of Kahoot as a formative assessment technology. The participants watched a YouTube video on how to create Kahoot on an overhead projector:https://www.youtube.com/watch?v=KJgZZQcsSPk

Then the participants played a Kahoot game made by the researcher. The researcher addressed the participants' questions with clarity. The researcher reviewed the participants' experiences

using Kahoot as a formative assessment tool in the second workshop. Data generated in this phase helped to answer research questions two and three.

Phase 2: To further lay the foundation of this study, the researcher then visited and observed each of the ten primary school mathematics teachers designing and using Kahoot to assess the learners in their respective mathematics classrooms. The researcher observed the teachers using Kahoot to formatively assess the learners learning. According to Kawulich (2005), this data gathering method is helpful in accessing events data as it follows the interpretive paradigm and qualitative research. The researcher was immersed in the study and gained rapport and trust from the participants. This exercise took place outside of the normal teaching time so as not to disrupt lessons in compliance with the gatekeepers' requirements ***(see, Appendix 1 principal approval letter)***. The data generated in this phase helped answer research questions two and three. Furthermore, teachers designed their Kahoots to assess learners' conceptual understanding of mathematics. **Figure 9** is a Kahoot game designed by a participant.

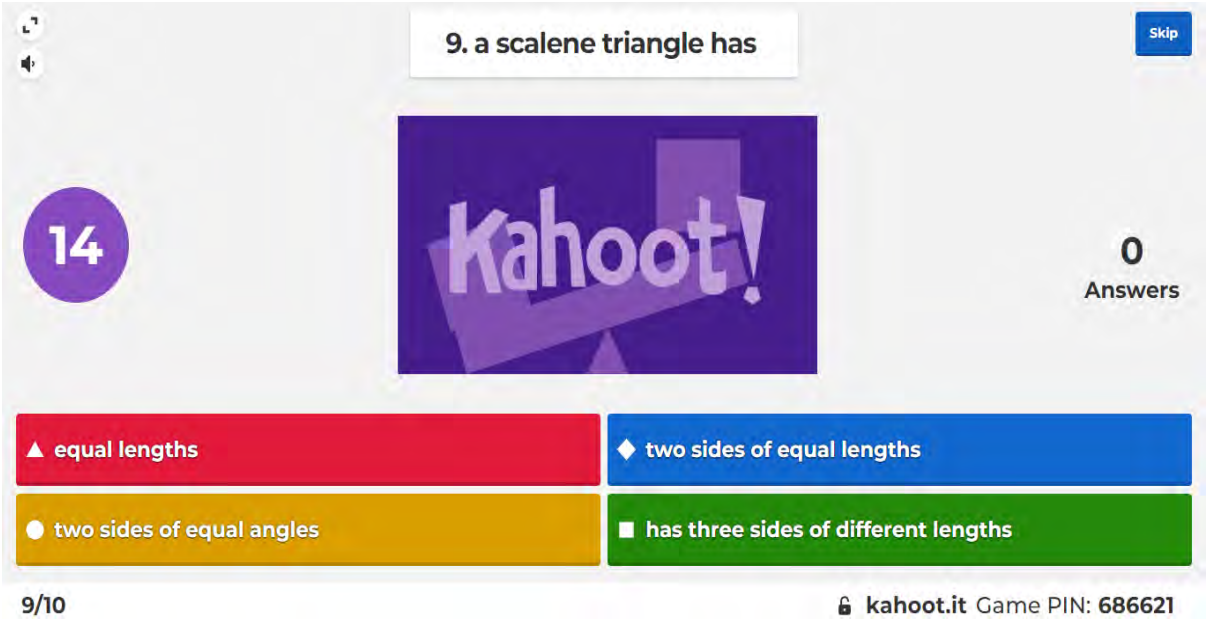


Figure 9: Kahoot game

Phase 3: After completing the observation task, participants were requested to participate in a focus group interview ***(see, Appendix 8)***. This was done for triangulation purposes, and the generated data contributed to the other data sets. The researcher engaged all the ten selected primary school mathematics teachers (participants) together and facilitated a discussion among them. This exercise allowed the researcher to get diverse views from the participants on the use

of Kahoot as a formative assessment technology. The data generated in this phase helped answer research questions two and three.

Phase 4: Structured questionnaires were administered to the ten research participants. The intended time frame for completion of answering the questionnaires by participants was one day from the date of receiving the questionnaires. The aim was to gain insights into primary school mathematics teachers' perceptions and attitudes on the use of Kahoot as a formative assessment technology after gaining the pedagogical and technological experiences of using Kahoot as an assessment technology. Data generated in this phase helped provide answers to this study's first research question.

Phase 5: At this phase, the qualitative and quantitative data were combined and analysed to understand the research problem better. Then the researcher reflected on the previous phases and the whole research. For the first research question, the researcher quantitatively analysed the data collected from the structured questionnaires using the descriptive statistics method. Descriptive statistic transform or summarises a set of data into either a visual overview such as a table or graph or into a single or a few numbers that summarise the data (Bertram & Christiansen, 2014). Data collected from research questions two and three were thematically analysed: allowing themes to come from the raw data.

5.3 Description of Selected Research Participants

Ten primary school mathematics teachers were purposively selected to participate in the study. There were five female and five male study participants. Out of the ten participants, seven were Primary Teachers Diploma (PTD) holders, while the other three were Bachelor's degree (BED) holders. The following table presents the participants and their teaching grades. Most of the participants (7) were between 30 and 39 years. Imperative to note is that one teacher was 43 years and had been teaching mathematics in primary school for over ten years. The names of the participants used in Table 6 below are pseudonyms.

Table 6: Background information of the participants

Teacher Pseudonym	Grade	Age	Gender	Academic qualifications	Number of years teaching mathematics
Jabu	1	43	Female	PTD	10
Glenda	2	38	Female	PTD	8
Lindiwe	3	32	Female	PTD	5
Jerry	4	30	Male	BED	6
Josh	5	34	Male	PTD	7
Winston	6	29	Male	BED	6
Olivia	7	35	Female	BED	7
Jack	5	30	Male	PTD	5
Nomuzi	6	33	Female	PTD	5
Victor	7	28	Male	PTD	5

5.4 Findings for Research Questions

5.4.1 Research question 1

What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?

5.4.1.1 Teachers' experiences in using Kahoot

Table 7 below shows participants' feedback when they were asked to rate their experiences in using Kahoot.

Table 7: Participants' experiences in using Kahoot

Teacher Pseudonym	Experience in using Kahoot
Jabu	Good
Glenda	Good
Lindiwe	Very good
Jerry	Excellent
Josh	Very good
Winston	Very good
Olivia	Excellent
Jack	Very good
Nomuzi	Very good
Victor	Very good

It is clear from **Table 7** above that most primary school mathematics teachers (6) rated their experience of using Kahoot as very good. On the other hand, teachers found to have 'Excellent' and 'Good' experience were few, with only 2 out of 10 responding with 'Good' and 2 out of 10 responding with 'Excellent'. Furthermore, the TAM constructs, Perceived Usefulness and Perceived Ease of Use underpinned the presentation of the quantitative data.

5.4.1.2 Usefulness of Kahoot

The information in **Table 8** shows the participants' feedback towards the usefulness of Kahoot.

Table 8: Participants' responses towards the usefulness of Kahoot

No.	Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	Using Kahoot makes assessment much easier	9	1	0	0	0
2	Using Kahoot increases learner motivation and participation	10	0	0	0	0
3	Using Kahoot allows me to create quizzes within a few minutes	6	2	1	0	1
4	Using Kahoot allows me to work easily with other learners outside the lessons	7	1	2	0	0
5	Using Kahoot makes me an effective teacher	9	1	0	0	0
6	Using Kahoot enables me to accomplish formative assessments more quickly	8	1	1	0	0
7	Kahoot is useful as an assessment tool; it has a feature of importing questions from the internet	8	1	0	1	0
8	Using Kahoot allows me to accomplish more than does using traditional tools	8	2	0	0	0
9	Kahoot provide access to the visibility of reports about the progress level of the class	9	0	1	0	0
10	Kahoot allows me to produce more in the time I have	7	2	1	0	0
11	Overall, I find Kahoot useful for my formative assessment	9	1	0	0	0
Actual number of responses		**90**	**12**	**6**	**1**	**1**

Teachers' responses on the usefulness of Kahoot were analysed to find out if Kahoot had any influence on their attitudes towards using it in class for formative assessment. The answers given for these depended on the Likert Scale and therefore, the answers were divided into 5

different levels of expression: Strongly agree, Agree, Neither agree nor disagree, Disagree and Strongly disagree. The results in **Table 8** above revealed that most participants found Kahoot a useful technology for assessing learner learning since their responses counted 90 for 'Strongly agree'. There were 12 occurrences of the participants' responses for 'Agree'. In addition, there were 6 occurrences for 'Neither agree nor disagree', 1 occurrence for 'Disagree', and 1 occurrence for 'Strongly disagree'.

According to **Table 8**, it shows that there is compatibility in the responses of teachers for a number of statements for the usefulness variable; these statements are: Kahoot makes design and setting of assessment easier; Kahoot increases learner motivation and participation; Kahoot provides instant feedback to the learners, and using Kahoot enables teachers to accomplish more activities and assignments more quickly. This compatibility in teachers' responses indicates that the usefulness of Kahoot in assessment has a significant effect on teachers' general attitudes towards using Kahoot, and this effect is regarded as positive, according to the responses supported in the structured questionnaires.

Teachers' responses concerning the usefulness of Kahoot were found to be positive. This indicates a strong belief in the usefulness of Kahoot within primary mathematics education since all the responses pointed to the fact that Kahoot saves time and effort in setting up and designing formative assessments and makes assessments much easier and more flexible than traditional assessment tools. There is also the belief that Kahoot eases communication with teachers and learners.

5.4.1.3 Kahoot ease of use

The information in Table 9 shows the participants' feedback towards the ease of use of Kahoot.

Table 9: Participants' responses towards the ease of use of Kahoot

No.	Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
12	Kahoot is generally easy to use on my subject	8	2	0	0	0
13	I find it easy to share reports with the other teachers and the school administration	7	1	0	1	1
14	I find easy to manage my subject files using Kahoot	8	1	1	0	0
15	I use Kahoot because it allows me to do assessments wherever I need	8	1	1	0	0
16	I find it easy to get Kahoot to do what I want it to do	8	2	0	0	0
17	It is easy for me to insert drawings in the iOS app or add YouTube videos to questions	8	2	0	0	0
18	I find the use of Kahoot clear and easy to understand	9	0	1	0	0
19	I find it easy to download reports in the spreadsheet	10	0	0	0	0
20	Overall, I perceive Kahoot technology easy to use	9	1	0	0	0
Actual number of responses		**75**	**10**	**3**	**1**	**1**

The results in **Table 9** above revealed that most participants find Kahoot easy to use. The participants were asked to specify the extent towards the ease of using Kahoot for formative assessment. Teachers were asked to respond on a 5-point rating scale: (i) Strongly agree, (ii) Agree, (iii) Neutral, (iv) Disagree, (v) Strongly disagree. The most notable response was strongly agree with 75 occurrences from **Table 9.** There were 10 occurrences of the participants' responses for 'Agree'. In addition, there were 3 occurrences for 'Neither agree nor disagree', 1 occurrence for 'Disagree', and 1 occurrence for 'Strongly disagree'. **Figure 9** below shows the screen that appears on the learner's device when responding to questions in a Kahoot game. The game host displays a timed question with possible answer choices. The players select an answer they think is correct for the question displayed on the game host screen. After choosing the colour keys, feedback is shown instantly on the scoreboard. It is easy to play Kahoot because the players select an answer by corresponding the game host colour keys with theirs.

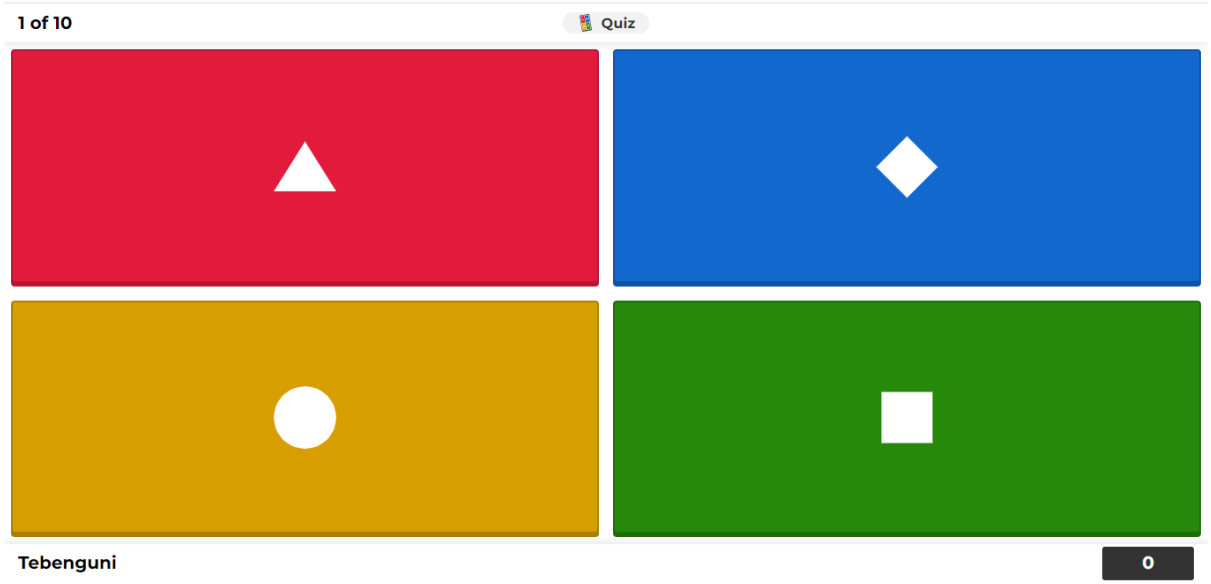


Figure 10: Kahoot colour keys for answering

Figure 11 below shows the feedback given to the player after choosing colour keys. The Kahoot players receive either a Correct, Incorrect or Time's up response if a question was not attempted. The number of questions attempted is displayed on the top-left, while a player's name is displayed on the bottom-left.

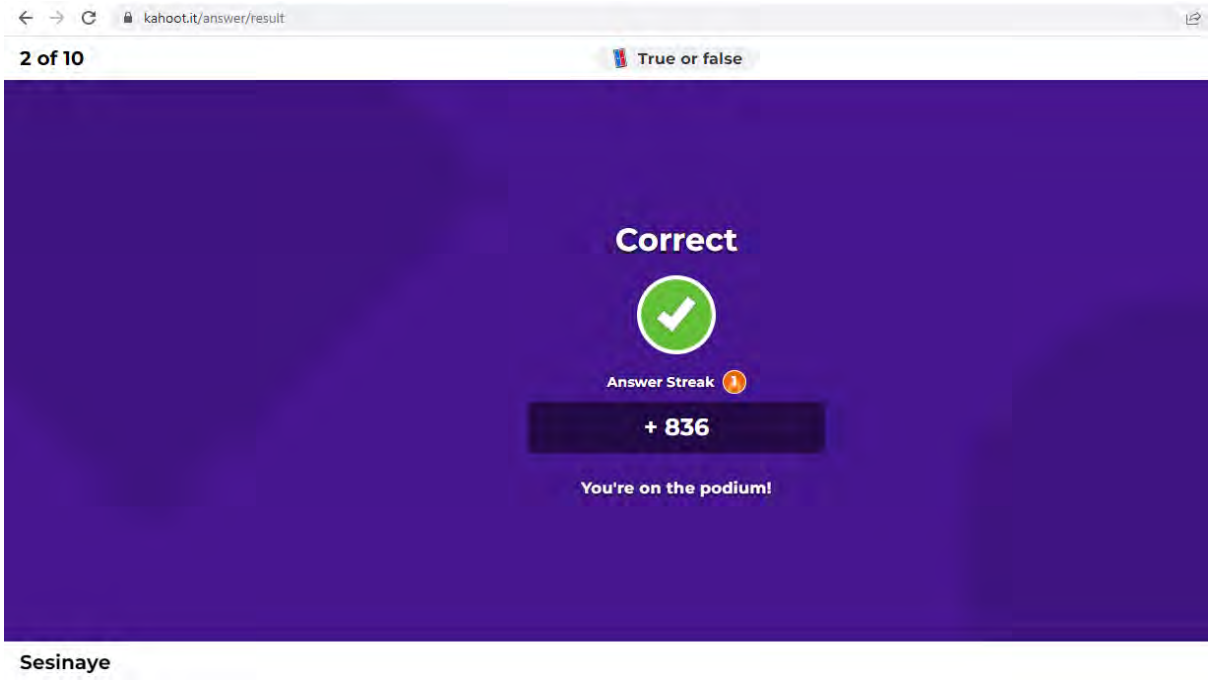


Figure 11: Kahoot instant feedback on learner devices

Perceived ease of use is an individual's perception that it requires no cost or effort to adopt a new system or technology (Cheema et al., 2013). Perceived ease of use refers to how effortless the participants perceive using Kahoot will be. Kahoot is an online quiz program that is free, easy to set up and use and fosters learning in a group setting (Zakia, 2019). This result supports the findings of Ranieri et al. (2021), study on *Game-based Student Response System,* who found that players answer on their own devices while questions are displayed on a shared screen. Furthermore, the results show that Kahoot is easy to use as there were 75 out of 90 occurrences selected for strongly agree. For instance, in a study conducted in Turkey with Language college students by Yıldırım and Sadık (2021), *Using Kahoot as a Multimodal Tool*, Kahoot was used for assessing the experimental group while the control group was assessed using the traditional method. The findings showed statistically significant differences in learning performance and motivation between the two groups. The experimental group got higher scores than the control group, and the motivation of students in the experimental group was much higher than that of the control group.

5.4.2 Research question 2

What are the primary school mathematics teachers' enabling and constraining factors for using Kahoot as a formative assessment technology?

The researcher used data generated from reflective journals, workshops, focus group interviews, and observations to respond to this question. Major themes that emerged from the different data generation tools are discussed below:

5.4.2.1 Enabling factors of using Kahoot as a Formative Assessment Technology

Enabling factors are defined as factors that make it possible (or easier) for individuals or populations to change their behaviour (Karlsson et al., 2020). Below is a presentation of the enabling factors of using Kahoot as a formative assessment technology:

5.4.2.1.1 Provision of financial support for schools to implement the use of technology in the classroom

One of the factors identified by participants as enabling the use of Kahoot as a formative assessment technology was the provision of financial support to purchase ICT resources required by schools could open opportunities to access ICT in schools. A study conducted by Muhametjanova and Çağıltay (20160, *Integrating Technology into Instruction at a Public University in Kyrgyzstan,* found that allocating the financial budget to purchase ICT resources

required to use Kahoot as a formative assessment technology could enable the use of Kahoot in the classroom. According to Rahim Sajid (2013), possible enablers include providing monetary and technical support to schools; and financial support from the government. These sentiments were endorsed by Olivia, who stressed that:

> *"The school must direct a huge chunk of money to purchase ICT resources like computers, projectors and data bundles."*

Jerry was for the idea that:

> *"The Ministry of Education must give schools enough money to kick-start using technology for assessing the learners."*

In a similar discourse, Jack believed that:

> *"Principals should buy ICT resources required in their schools to open opportunities for teachers to use Kahoot in class."*

Jack posed a thought-provoking question:

> *"We live in the Fourth Industrial Revolution era; what is the government doing to ensure that our learners receive quality education delivered online?"*

Lastly, Nomuzi believed that:

> *"Teachers who use technology like Kahoot to assess the learners should be provided with incentives to encourage them."*

From the perceptions of Olivia, Jerry, Jack and Nomuzi, the researcher believes that the provision of financial support to purchase ICT resources needed in schools to support the use of technology in the classroom for teaching and learning could enable the use of Kahoot by teachers to gauge learner understanding of mathematical concepts. This is because most rural schools do not have funds to acquire ICT resources to support teaching and learning. This is supported by Duraku and Hoxha (2020), who pointed out that the lack of sufficient technological tools affects the use of technology to support teaching and learning.

5.4.2.1.2 The provision of technical training for teachers

The provision of technical training for teachers is a possible enabler of using Kahoot as a formative assessment technology in the classroom. A study carried out in Malaysia by Ghavifekr and Rosdy (2015), *'Teaching and Learning with Technology: Effectiveness of ICT*

Integration in Schools', found that if there is a lack of technical assistance teachers do end up fail to incorporate technologies in the classroom. During the data generation and analysis stage, technical support for teachers was identified as one of the factors that could open opportunities for teachers to learn and train on Kahoot as a formative assessment technology in the classroom. Almanthari et al. (2020) corroborated this idea by stressing that offering technical support for teachers is a possible enabler for the use of Kahoot in the classroom. Though most of the teachers selected in this study were technology-savvy but lacked the expertise in using Kahoot in the classroom thus, the researcher conducted a workshop with the participants on using Kahoot as a formative assessment technology. Therefore, the participants needed to participate in the workshops to master the expertise of using Kahoot to assess learner conceptual understanding. For example, one participant in a focus group interview stated that:

> *"In 2017, all the teachers in my school were workshopped on teaching using technology. This made me realise the value of using technology in the classroom. I think technical training is vital for teachers to stay at par with the changing technology and the curricula. For example, one facilitator demonstrated how to draw teaching and learning aids on the Paint App. That session was fruitful to me"* (Glenda).

From the perception of Glenda, the researcher believes that the provision of technical support for teachers is a possible enabler of using Kahoot as a formative assessment technology in the classroom. Schools that use an information systems like computers, tablets and mobile phones usually deal with software-related problems. Therefore, it is essential that ICT gadgets in the school are fixed if they have technical errors or faults. This is supported by Ghavifekr and Rosdy (2015), who stressed that teachers would be discouraged from using computers because of fear of equipment failure. Tusiime et al. (2020) concurred that technical faults might discourage educators from using digital tools in their teaching because of the fear of equipment breaking down during a lesson. To illustrate, Josh stated that:

> *"I think most teachers are not using Kahoot in their classrooms because they lack proper training. It is embarrassing for a teacher to use a laptop in front of 50 learners if the teacher is not competent in using one. That lesson can be chaotic, I think. To redress the situation, I think the Swaziland Ministry of Education must train teachers on using technology in the classroom."*

Olivia added that:

"It's not that teachers hate teaching with technology. Teachers are not well-versed in using Kahoot in the classroom. It is a gap that teacher training workshops can bridge. Another issue is that we now teach learners who are digital natives, so a teacher must be competent in using technology in the classroom."

The above assertions by Glenda, Josh and Olivia show that technology knowledge, the Fluency of Information Technology (Mishra & Koehler, 2006) is imperative for teachers regarding the use of Kahoot to formatively assess the learners. The focus group interviews conducted with the selected ten participants stated that technical assistance could open opportunities for teachers to use technology for teaching and learning. According to Toma et al. (2021), the provision of hardware in a school with proper training and support facilitates the use of Kahoot for formative assessment in schools. Similar sentiments were endorsed by Jerry, who pointed out that:

"For me, I think proper training and technical support can go a long way in the teaching profession. This can sharpen the skills of the teachers and make them effective in their work."

When probed further by the researcher, Jerry went on to state that:

"Now that there is a new syllabus in grade 3 known as the Competency-Based Education, ICT has been introduced as a new subject; thus, teachers need technical assistance and proper training to be abreast with technology education. I think this can give the teachers a platform to express their confusion and fears regarding the new syllabus. So training is key for me."

Although most of the participants concurred that technical support was an important enabler for the use of Kahoot as a formative assessment technology in the classroom, Jabu held a slightly different view:

"What I can say is that as teachers, we do need technical assistance and proper training to be at par with the different needs of the learners in the twenty-first century. But the issue here is that most teachers have a negative attitude against being workshopped; they are stereotyped and fear change."

These statements by Jerry and Jabu indicate that they find technical assistance and proper training as an enabling factor for teachers to use technologies like Kahoot to formatively assess learners. This supports the findings of Kundu, Bej and Rice's (2021) *Time to engage:*

Implementing math and literacy blended learning routines in an Indian elementary classroom' who reported inadequate technical support to maintain the digital equipment as a chronic problem discouraging educators from teaching with technology. This also confirms the findings of Tusiime et al. (2020), in their study conducted in Uganda, '*Teaching Art and Design in a Digital Age: Challenges Facing Ugandan Teacher Educators,'* in which they found out that most educators are unable to use technology in the classrooms because they did not receive sufficient pedagogical and technological training in the use of digital technologies.

5.4.2.2 Constraining factors of using Kahoot as an assessment technology

In the context of this study, a constraining factor is any condition that makes it difficult to make progress or to achieve an objective of using Kahoot to formatively assess the learners (Öz & Ordu, 2021). Below is a presentation of the constraining factors of using Kahoot as a formative assessment technology: lack of high-speed internet connectivity; and lack of basic technological knowledge for using Kahoot in teaching.

5.4.2.2.1 Lack of a high-speed internet connection

One of the factors identified by participants as a challenge to the use of Kahoot as a formative assessment technology was the lack of high-speed internet connection. The teachers acknowledged that a poor or slow internet connection would result in Kahoot players losing track of progress. A high-speed internet connection is essential in a Kahoot game because the players compete based on the time taken to respond to a question and its accuracy. This is supported by Tran et al. (2019), who indicated that when students cannot get back once they lose their connection during the game can easily cause disruption in the classroom. Many researchers argue that the downside of Kahoot is getting connected to the internet, whether to create the game or to play the game in the classroom (Zarzycka-Piskorz, 2016; Sabandar, Supit & Suryana, 2018; Tran et al., 2019). The generated data revealed that most teachers believed that poor internet connection was a constraining factor for using Kahoot as a formative assessment technology. It demoralises learner morale and can lead to frustration. Josh, for example, pointed out that:

> *"The internet speed was a bit slow, so it impacted the Kahoot game the learners were playing."*

When probed further by the researcher to explain how the slow internet speed impacted the Kahoot game, Josh continued:

"I think that the internet connection was not that strong enough. This dampened the spirit of the learners to play the game. Remember that time is the most crucial element when playing Kahoot. Even if all the learners can answer all the questions correctly, the winner is selected based on the time taken to respond to the question. Most of my learners are hyperactive, so a slow internet can demotivate their will to play the game."

In the same manner, Jack, Nomuzi and Victor identified low-speed internet connectivity when asked to state constraining factors to using Kahoot for assessing the learners; for instance, Jack stated:

"Technical problems in the classroom such as lack of a fast internet connection."

Nomuzi identified:

"Low-speed internet provided in the school."

Victor stressed that:

"Strong internet connection is not available to all learners and teachers at home."

Another participant shared similar sentiments:

"There was a delay in connecting to the internet. I think the speed of the WIFI router is not fast enough; thus accommodating so many computers is a challenge" (Winston).

Olivia added that:

"Today's lesson did not go down well. Ten of my learners were not able to play the Kahoot game. With gloomy faces, they watched other learners playing the Kahoot game. The situation was beyond my control; the internet was too slow today."

One of the teachers, Glenda, expressed a concern that:

"Deliberate power cuts and poor internet connection affect the assessment of the learners as the computer depends on the availability of electricity to function. If there is no electricity assessing the learners using the Kahoot technology will be impossible."

These statements indicate that the teachers find a high-speed internet necessary when assessing learner content knowledge using Kahoot. This supports the findings of Pratolo and Lofti (2021) in their study on *'Students' Perceptions toward the Use of Kahoot! Online Game for Learning English'* found that Kahoot is dependent on the internet network; it makes students difficult to assess because sometimes the internet network is too slow. This also confirms the findings of

Verma et al. (2019) in their study on *'Emerging Practices in Game-Based Assessment'* found that an internet connection that is too slow is a challenge to game-based assessments relying on the internet.

5.4.2.2.2 Lack of basic technological knowledge for using Kahoot in formative assessment

Lack of basic technological knowledge for using Kahoot in the classroom was another constraining factor identified by most teachers of using Kahoot to assess learners' learning. This view is supported by Nguyen and Yukawa (2019). They argue that many teachers lacked the knowledge and skills to use Kahoot and were not enthusiastic about changes and integration of supplementary learning associated with bringing computers into their teaching practices. A few teachers stressed that they lacked the technological knowledge of using Kahoot as an assessment technology. For instance, Jerry identified:

> *"Lack of experience with modern educational technologies."*

For Nomuzi, it was:

> *"Lack of students' experience in the use of a computer."*

Other teachers mentioned:

> *"Keeping up with the tremendous development in new technologies."*

Jack believed that:

> *"Difficulty in preparation of the material to be used on Kahoot."*

The above comments by the participants indicate that they find using Kahoot as a formative assessment technology in mathematics lessons beneficial. This supports the findings of Martínez-Jiménez et al. (2021) *'Kahoot as a Tool to Improve Student Academic Performance in Business Management Subjects',* who found that students' academic results improve when Kahoot is used as an evaluation tool. This also confirms the findings of Aldana (2020) in a study conducted in Mangilao with two geometry classes, *'The Effects of Review Games Using Kahoot! On Students' Quiz Scores'* found that the use of Kahoot had a positive impact on the performance of geometry students on their quizzes compared to the outcomes of a traditional teacher-led formative assessment. Having presented the enabling and constraining factors of using Kahoot as a formative assessment technology, the focus shifts to the third research question of this study.

5.4.3 Research question 3

How can primary school mathematics teachers make use of Kahoot as a formative assessment technology?

To respond to this question, the researcher examined primary school mathematics teachers' pedagogical and technological experiences or insights in using Kahoot as a formative assessment technology. Thus, during the data collection and analysis stage, the researcher identified a number of recurring themes that linked well to the third research question. The themes demonstrate how the participants use Kahoot as an assessment technology, which aligns with the study's theoretical framework. The researcher used data generated from reflective journals, workshops, focus group interviews and observations for the third research question. Major themes that emerged from the different data generation tools are discussed below:

5.4.3.1 Kahoot maintains the attention and focus of the learners

The generated data showed that all of the participants agreed that Kahoot in their mathematics classrooms maintained their learners' attention. Seven of the ten teachers stated that Kahoot helped their learners to recall and memorise information. In contrast, three others highlighted that participating in Kahoot assignments has helped their learners to stay focused. These findings confirm how cognitive functions, such as concentration, focus, memorisation, and attention, are stimulated by social interaction, which is in line with Vygotsky's (1978) beliefs about the role of the zone of proximal development (ZPD) in facilitating learners' cognitive growth and improving higher-order learning. For example, Jack believed that:

> *"Kahoot helped me memorise words because I remember the pictures"* (Jack).

Another aspect reported by teachers is how the animation impacted the concentration of their learners. A majority of the teachers mentioned that the sound animation effects found in Kahoot sustained the engagement of their learners and focus, which is consistent with Wang and Liberoth's (2016) experiments with Kahoot and is linked to Malone's (1981) ideas of the role of music and sounds in stimulating students sensory curiosity. For example:

> *"When an audio file is played, it creates a feeling of suspense and encourages the learners to concentrate and work harder"* (Olivia).

Another teacher mentioned that:

> *"The music makes me nervous, but at the same time, it motivates my learners to keep listening"* (Nomuzi).

On the contrary, one teacher stated that music and animation in Kahoot games negatively affected the concentration of her learners, and they felt distracted by the music and the time pressure. For instance, Lindiwe expresses that:

> *"There was no time to think of the questions; I think the learners were distracted by the music and had to answer quickly before the time ran out."*

A primary barrier to concentration was the length of the lesson and the time of the day in which the mathematics class took place. Most teachers mentioned that Kahoot relieved feelings of exhaustion and rejuvenated their learners' concentration and participation. A teacher referred to his experience with Kahoot as giving his learners a chance to recharge when they felt drowsy. Most teachers concurred that their learners concentrated more during class when Kahoot was used as an assessment technology. Certain declarations provided by the teachers showed their positive feelings about using Kahoot concerning attention and focus. Comments illustrating this view from this study were:

> *"Playing Kahoot helped my learners pay attention and focus"* (Jerry).

> *"Kahoot kept my learners awake, particularly in the afternoon mathematics classes when the learners were tired"* (Victor).

The above comments by the participants indicate that they find the use of Kahoot as a formative assessment technology in mathematics lessons helpful. This supports Alawadhi and Abu-Ayyash's (2021) findings in their study conducted in the United Arab Emirates, *'Students perceptions of Kahoot',* which found that Kahoot sustains students' attention and focus during the lesson. This also confirms the findings of Gorard et al. (2021), in their study conducted in the Netherlands with 97 primary schools over five months *'Is Technology Always Helpful? A Critical Review of the Impact on Learning Outcomes of Education Technology in Supporting Formative Assessment in Schools'* found that teachers and students receive immediate feedback from the system indicating whether their answers were correct. The results showed a positive effect on maths measured using a standardised test. This is also in line with Licorish et al. (2018), who found that the use of Kahoot triggered positive attention and focus in the classroom.

5.4.3.2 Kahoot increases interaction and engagement among the learners

The generated data show that Kahoot increased learners' opportunities for interaction with peers and instructors and facilitated learners' deep engagement with content materials. All of the teachers reported that Kahoot encouraged active class engagement, and seven teachers mentioned that Kahoot improved the collaborative skills of their learners. For instance, Winston stated that:

> *"The learners are enthusiastic about collaborating with their classmates to answer questions on the Kahoot game and see their names displayed on the scoreboard."*

Another teacher stressed that:

> *"My mathematics learners are more involved and active in class"* (Glenda).

These comments show elements of collaborative and active learning, which ties well with Aktekin, Çelebi and Aktekin (2018), *'Let's Kahoot Anatomy'* a study conducted in Italy which found that the observed classroom environment benefits can be listed as higher attendance and participation, and more focused and engaged students in class. Furthermore, teachers stated that participation and discussion of their learners with peers kept them on task. These conclusions demonstrate that teachers appreciated the peer learning enabled by Kahoot. In addition, data analysis revealed that the gamification elements embedded in Kahoot had been found to promote social interaction, as propounded by Vygotsky (1978).

Furthermore, many teachers suggested that Kahoot was particularly helpful in changing the dynamic of the lesson, as the learners seemed to feel that they were part of the discussion rather than playing the passive role. Compagnoni (2021) concurs in his study on *'Learning Italian as a Foreign Language via Virtual Museum Tasks'* that Kahoot utilises playful and colourful graphics and audio to promote student engagement. One of the teachers expressed his view that:

> *"I feel that Kahoot increased classroom interaction. Learners talk to each other and ask for clarifications"* (Jerry).

Kahoot gave the learners a chance to be active and participate in class. For instance, Olivia stated that:

> *"One learner usually sat at the back and did not contribute during teaching and learning, but now that we are using Kahoot, he is active in class."*

Another participant stressed that:

> *"When I use Kahoot to assess the learners, boys seem to be interacting with girls, something which was rare in the traditional assessment methods"* (Winston).

Another important point that emerged from the data was the role of anonymity in increasing learners' participation. Kahoot allows players to use nicknames that encourage wider participation during gameplay. During the data generation stage, some teachers expressed that their learners felt more comfortable using nicknames while playing because they were concerned about selecting an incorrect answer. In addition, four teachers mentioned that their learners preferred to use nicknames because they thought it was fun. For instance, Lindiwe stressed that:

> *"Nicknames made the learners feel relaxed."*

Students felt comfortable answering anonymously in class, making the classroom friendly and fun (Wang & Tahir, 2020). This is probably because anonymity in digital games provides a safe environment where students can participate without the fear of embarrassment if they get wrong answers (Plump & LaRosa, 2017). Jack stressed that:

> *"Some learners like to use funny names, which I think is amusing. It helps them get to know each other more."*

Some players indicated a significant interest in identifying themselves if they get high scores on the scoreboard. It makes them feel proud and allows them to show off their status and celebrate their efforts. Nomuzi pointed out that:

> *"One learner stated that he likes to use his name so that everyone can see that he is a good student."*

In addition, teachers appreciated the competition experienced by the Kahoot players while participating in the game, including the use of points and status. Victor mentioned that:

> *"I like to see the names of the top ten on the scoreboard; it makes me feel special that I have taught the learners."*

Lastly, Glenda stated that:

> *"Kahoot, give us a chance to discuss the correct and wrong answers as a class."*

These statements by the teachers indicate that they find Kahoot as a useful formative assessment technology in mathematics lessons. This is in line with Holbrey (2020), who reported that Kahoot gave students more opportunities to interact and engage with the lecturer, peers and lecture content by providing a fun platform on which to engage. Also, the above comments support Ashtari and Taylors' (2021) findings in their study conducted in Jamaica *'Winning Together: Using Game-Based Response Systems to Boost Perception of Learning',* which found that student engagement tends to be significantly boosted when Kahoot is used in the classroom.

5.4.3.3 Kahoot elevates motivation and competition among the learners

The second identified theme is motivation, which is related to students' attitude, desire, interest, curiosity and the efforts they show while participating in Kahoot. All of the teachers reported that Kahoot increases motivation and competition among the learners. For instance, Josh stated that:

> *"Most of my students show a keen interest during mathematics lessons because I am using Kahoot to assess them. This has also led to competition among the learners."*

Research conducted by Campillo-Ferrer et al. (2020) on *'Gamification in Higher Education: Impact on Student Motivation and the Acquisition of Social and Civic Key Competencies'* indicate that learning in the form of gamification such as Kahoot can elevate an individual's motivation compared with the traditional classroom setting. Sabandar, Supit and Suryana (2018) also agree that Kahoot is an effective medium to motivate and engage learners in the classroom. All of the teachers (N=10) believed that Kahoot brought friendly competition to the classroom and improved learner motivation to participate in the classroom activities and assessment. These findings suggest that Kahoot has become an integral modern tool of education in the 21st century that teachers can use in the classroom and serve as a means of enhancing motivation and engaging students to learn. Kahoot motivates the learners because it satisfies their desire for challenge and fantasy, which is consistent with Baszuk and Heath's (2020) study on *'Using Kahoot to Increase Exam Scores and Engagement',* which found that digital games like Kahoot create active engagement due to the qualities of competition and engagement. These findings have also been recently confirmed by Wang and Tahir (2020) in their study *'The effect of using Kahoot for Learning',* which found that the goal of Kahoot is to increase engagement, motivation, enjoyment, and concentration to improve learning performance and classroom dynamics. For example, **Figure 12** displays the points as the players in the game score them. A player with the highest score is placed first on the scoreboard,

while a player with lower scores is placed at the bottom. The players' ranking on the scoreboard changes as the scores change during the game, which heightens competition among the players. Though Lilly ranked fourth, Kahoot rewarded her with extra points for getting multiple questions right in a row.

Figure 12: Kahoot scoreboard

For instance, Nomuzi noted that:

> *"When the learners are playing against other learners, they are motivated to work harder to win the game."*

Another teacher stressed that:

> *"The learners are excited and motivated when they see their names suddenly excelling in the leader-board"* (Jack).

Prieto et al. (2019) concur that students can see their position in the ranking of the scores, as the platform generates a classification once the different questions have been answered. Lindiwe shared the same sentiments:

> *"Since I've started using Kahoot in class, the learners need more clarity on mathematical concepts to do well during the quiz."*

When examining the generated data, 7 out of 10 teachers also pointed out that the scoreboard sparked motivation in their learners and increased their self-esteem. Many teachers conveyed that their learners are likely to attend mathematics classes knowing that Kahoot will be used in class. For example:

> *"I think maybe students showed more interest in mathematics class due to the integration of digital games"* (Jerry).

More than seven teachers highlighted that they were more optimistic about mathematics because they enjoyed the variation that Kahoot brought to the lesson. Another participant mentioned that:

> *"I am more interested in mathematics classes, especially when I see my learners attaining high scores in Kahoot"* (Lindiwe).

As stated earlier, teachers thought that their afternoon mathematics classes were exhausting and that using Kahoot sustained the learners' attention and kept them alert. The researcher noted that teachers made positive remarks about using Kahoot as a formative assessment technology during the data collection stage. Most teachers mentioned that their learners concentrated more when competing against other learners. However, these findings emphasise the importance of competition in boosting learners' motivation. These results are underpinned by the seminal works of Wang and Tahir (2020); Biçen and Kocakoyun (2018); Plump and Rosa (2017). Thus it is clear that excitement motivated by competition among the learners leads to higher learner engagement in class.

5.4.3.4 Kahoot improves learning and knowledge retention in the learners

The data analysed in this study show that Kahoot significantly improved learning and knowledge retention in the learners. Most teachers perceived Kahoot to enhance the learning performance of the learners. Six teachers stated that Kahoot had a positive impact on learner achievement, and seven teachers said that Kahoot assisted their learners in revising for the mid-year exam. Glenda strengthened these sentiments by stating that:

> *"I think Kahoot assisted my learners in revising for the mid-year examination. The learners' grades have improved since I use Kahoot to assess them."*

Olivia mentioned that:

> *"Kahoot helps my mathematics learners to study and remember correct answers."*

Teachers' feedback indicated that when learners participated more in Kahoot, there was a clear improvement in their conceptual understanding of mathematics. Furthermore, teachers stated that Kahoot supported learning and helped their learners to recall previous information and aid understanding of mathematics. These findings are in accordance with findings reported by Arif et al. (2019); Ting, Lam and Shroff (2019), who found that Kahoot helps the learners to relate to learning and classroom notes successfully, put more effort into revising lessons, recalling important points of a particular topic in a more enjoyable manner, and discover new information, improve learners' retention power, and monitor their progress. For instance, Jabu noted that:

> *"Kahoot improved the learners' understanding of mathematical concepts. I think the learners are more prepared for taking the weekly test after playing Kahoot."*

The teachers pointed out two learning outcomes of using Kahoot in class: knowledge retention and identifying learning barriers. Seven teachers described Kahoot as a valuable tool to strengthen the knowledge of their learners, and five teachers stressed that Kahoot helped them identify the learners' learning weaknesses and mistakes. For example, Victor stated that:

> *"Kahoot allowed the learners to correct their mistakes."*

Josh added:

> *"The failing and passing percentage of each question is displayed on Kahoot. Therefore, I can see questions that the learners do not understand."*

Kahoot is more likely to enhance learner conceptual understanding due to the use of visuals, graphics, and instant feedback. A growing literature on educational gamification shows that Kahoot is a great tool to engage the learners in active learning. Student engagement tends to be significantly boosted when Kahoot is used in the classroom (Tran et al., 2019). Singh et al. (2019) reported similar results that Kahoot utilises playful and colourful graphics and audio to promote student engagement. Pektas and Kepceoglu (2019) found that it generates cooperation among students. **Figure 13** below shows how the players get immediate feedback on their devices. A screen with answer choices appears with shapes and colours. Players then click on the colours and shapes that match with their options and quickly get feedback on whether the answer is correct or incorrect and the points accumulated are displayed.

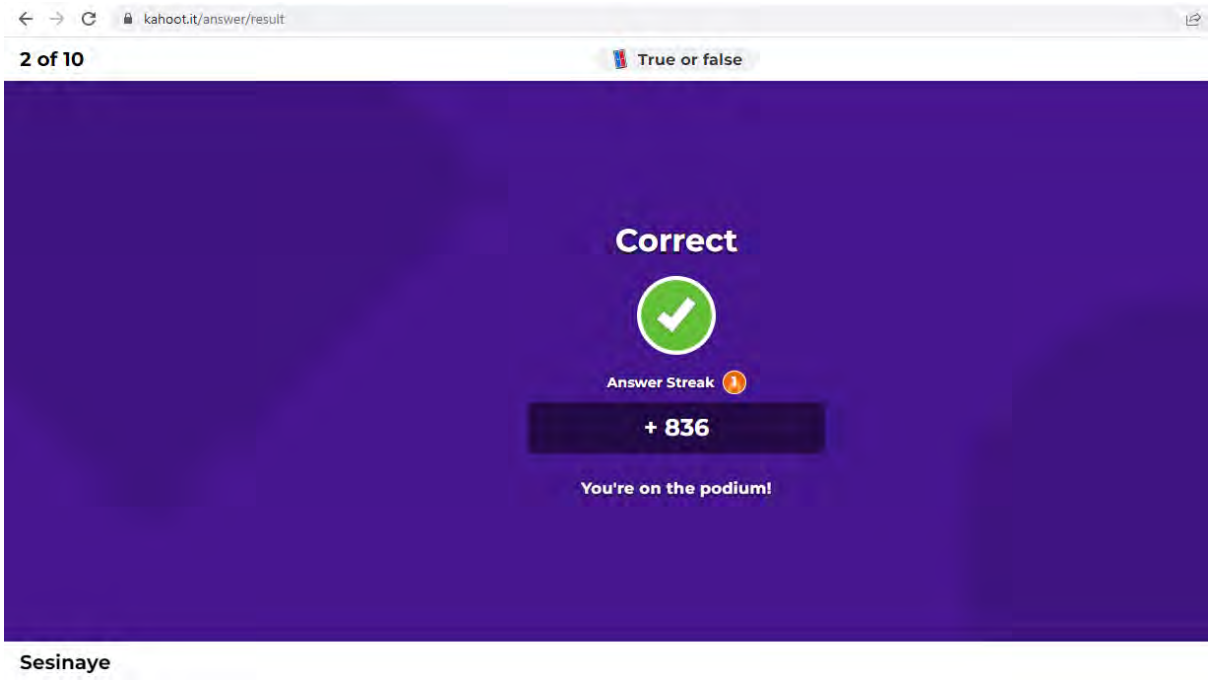


Figure 13: Kahoot instant feedback on learner devices

For example, Lindiwe observed that:

> *"I find it valuable when discussing the wrong answers with the learners."*

Winston mentioned that:

> *"I find the immediate feedback helpful it allowed the class to discuss each other's mistakes and learn from one another."*

Similar sentiments were held by Josh, who stressed that:

> *"I am now able to give feedback to the learners in time. This reinforces their learning. I was able to identify the questions which were a challenge to the learners."*

Conversely, Licorish et al. (2018) argue that despite solid evidence that Kahoot and other Game-based Student Response System (GSRS) increase student attention, motivation and engagement, it remains unclear whether Kahoot leads to greater learning outcomes compared to traditional methods and GSRS. This line of thinking is supported by only two teachers who mentioned they do not believe Kahoot will improve the learners' mathematical conceptual understanding, which is consistent with Baszuk and Heath's (2020) findings. For instance, Jerry stated that:

"I don't think playing Kahoot will help my mathematics learners pass the examination."

Likewise, Nomuzi expressed concern that:

"I am using Kahoot to revise, but I am pessimistic it will help my learners pass the exam."

These sentiments by the teachers are in line with the study of Chiang (2020) *'Kahoot in an English as a Foreign Language Reading Class'* who reported that Kahoot improves the quality of the learning process in terms of students' attention, focus, participation, knowledge retention, revision, and enjoyment. This means that Kahoot can create opportunities for the learners to identify their learning difficulties and retain knowledge. This is also consistent with the findings of Korkmaz and Öz (2021), *'Using Kahoot to Improve Reading Comprehension of English as a Foreign Language Learners'*, who found that Kahoot offers students the opportunity to assess their progress through a fun and interesting atmosphere, which helps to retain information.

5.4.3.5 Kahoot provides the learners with fun and enjoyment

Fun and enjoyment are among the most experienced activities by learners, as noted by the research participants as they were using Kahoot to assess the learners. Most teachers acknowledged that fun is one element found in the Game-based Student Response System (GSRS). The students enjoy and feel motivated when assessed using Kahoot because they compete with their friends to become a winner, creating a classroom competition (Zakia, 2019). Playing Kahoot at the end of the class whips up the learners' enthusiasm to learn. It adds a fun element to the lesson (Aktekin et al., 2018). For example, Nomuzi noted that:

"There is a lot of positive energy in the classroom when the learners participate in Kahoot."

Sharing the same view as Nomuzi, Glenda and Jack further mentioned that:

"Mathematics classes are more fun with Kahoot. Kahoot created a happy atmosphere in the classroom" (Glenda).

"The competitive atmosphere created by Kahoot in class is fun" (Jack).

However, these comments from the teachers seem to provide evidence that Kahoot contributes to a more enjoyable classroom experience. Teachers also found Kahoot to be easy to use as one

teacher observed that it was quick and easy to use. Furthermore, seven teachers stated that the score ranking obtained while playing Kahoot added an element of joy in class and made the learners proud of their achievements and boosted self-esteem. Jerry, Olivia and Jabu acknowledged that many of their learners like to post their academic achievements on social media to celebrate their achievements. For instance, Victor stressed that:

"My learners are posting the summary of results of their Kahoots on WhatsApp."

A common opinion from teachers' feedback was that using gamification in the classroom reduces boredom. This is consistent with Angkotasan et al. (2019), who found that Kahoot is one of the main factors in improving the quality of learning in the classroom because it can create an atmosphere that is not boring for students. During the data generation stage, many teachers stated that gamification in the classroom brought positive energy. For example, Josh stressed that:

"Kahoot brought an enjoyable change to my mathematics class. The learners seem to enjoy it."

Also, Glenda pointed out that:

"My mathematics lessons are no longer dull and boring since I introduced Kahoot."

The fun and enjoyment experienced by the teachers have also been found by Głowacki et al. (2018) in their study of higher education institutions in Poland and Ukraine. Nomuzi also endorses these sentiments:

"Using Kahoot in the class made the top five learners very happy."

Winston stated that:

"It was quite an experience to participate in Kahoot because my learners were happy."

The above sentiments indicate that the teachers find Kahoot beneficial to the way they do formative assessment in mathematics lessons. The outcomes of this research are consistent with the results of Wirani et al. (2022) in their study conducted in Indonesia *'Evaluation of Continued Use on Kahoot as a Gamification-based Learning Platform from the Perspective of Indonesia Students'* in which they found that students are happy, excited, and enthusiastic when using Kahoot. In addition, students feel comfortable with the processes in Kahoot. Lecturers can add pictures or videos to the questions and answer choices. This also confirms the findings of Ahmed et al. (2022) in their study conducted in Iran *'An Empirical Study on the Effects of*

Using Kahoot as a Game-Based Learning Tool on EFL Learners' Vocabulary Recall and Retention', in which they found that fun, pleasure, and high motivation levels may be achieved by using Kahoot games in the classroom.

5.5 Chapter summary

The current chapter presented research findings from the data generated from the ten participants. The chapter also presented the quantitative results generated from structured questionnaires, which were underpinned by the two constructs of TAM: perceived usefulness and perceived ease of use. The qualitative findings were generated from workshops, focus group interviews, reflective journals and observations; they were underpinned by the two constructs of the TPACK framework: TK and TPCK. The findings presented in this chapter were a response to the research questions presented in chapter one. The results of the study, which are consistent with the methodology, have been clearly and correctly presented. The results were presented according to themes that emerged from the data analysis based on the research questions. The next chapter discusses the findings of this study.

CHAPTER SIX: DISCUSSION

6.1 Introduction

The previous chapter presented the results and findings generated from observations, workshops, structured questionnaires, focus group interviews, and reflective journals. In this chapter, the researcher presents an interpretation of the results and how the results fit with other studies. The discussion of key findings is divided into three parts: (6.2.1) Perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology, (6.2.2) Primary school mathematics teachers' enabling and constraining factors of using Kahoot as an assessment technology, and (6.2.3) Pedagogical and technological experiences or insights of primary school mathematics teachers in using Kahoot as an assessment technology.

6.2 Discussion of key findings

The fundamental objective of the study was to explore how primary school mathematics teachers use Kahoot as a formative assessment tool. To achieve the research objective, three research questions were involved, and these are summarised together with the research instruments used to respond to the research questions in Table 10 below.

Table 10: Summary of research questions and instruments used

Research question	Research instrument
1. What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?	Structured questionnaires
2. What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as a formative assessment technology?	Workshops, Observations, Focus group interviews, Journal reflections
3. How can primary school mathematics teachers make use of Kahoot as a formative assessment technology?	Workshops, Observations, Focus group interviews, Journal reflections

The research findings presented in the previous chapter are further discussed in this chapter in relation and contrast to the literature and response to the study's research questions.

6.2.1 The analysis of research question 1

What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?

The researcher used a standard scale for the attitude to respond to the first research question, which consisted of 5 levels to describe teachers' attitudes. The levels of attitude in this chapter were derived from the following formula:

$$\frac{100\,\%}{\text{Number of levels}} = \frac{100}{5} = 20$$

Table 11 below explains the standards for judging attitudes towards the use of Kahoot.

Table 11: Standards for judging attitudes towards the use of Kahoot

Percentage (%)	**Attitude**
0 – 20	Strongly negative
21 – 40	Negative
41 – 60	Neutral
61 – 80	Positive
81 – 100	Strongly positive

In order to analyse primary school mathematics teachers' attitudes towards using Kahoot as a formative assessment tool, the percentages were calculated in terms of their responses to questions relating to the use of Kahoot. Furthermore, attitudes were measured based on the standards for judging attitudes towards Kahoot usefulness (PU) and ease of use (PEU), as shown in **Table 12** below.

Table 12: Percentages and attitude towards Kahoot usefulness and ease of use

Contents of the attitude	**Percentage**	**Attitude**
Ease of use	84	Strongly positive
Usefulness	82	Strongly positive
General attitude	83	Strongly positive

As illustrated in **Table 12** above, the general attitude of primary school mathematics teachers is strongly positive with 83%. The results also confirm that the percentage of teachers for Kahoot usefulness is 82, and 84 for Kahoot ease of use. Therefore the teachers found Kahoot useful and easy to use.

The quantitative data analysis indicates that the attitudes of primary school mathematics teachers towards using Kahoot generally appear to be positive. Moreover, the results indicate that the PEU and PU factors have a strong positive influence on teachers' general attitudes towards using Kahoot in assessment, where strongly positive was the most selected from a 5-point rating scale: (i) Strongly agree, (ii) Agree, (iii) Neutral, (iv) Disagree, (v) Strongly disagree. The actual number of responses selected for strongly agree was 75 out of 90 for PEU; and 90 out of 110 for PU. Therefore, the positive attitude of teachers has formed a positive behaviour towards Kahoot, and accordingly, they were motivated to use Kahoot in their assessment further.

The qualitative results revealed by the workshop, observations, journal reflections and focus group interviews with the teachers - it was found that they support the quantitative results from the structured questionnaires. Furthermore, the results of the quantitative data show that teachers have positive attitudes towards using Kahoot, based on the fact that the teachers' responses are in accordance with some of the statements related to the PEU and PU of using Kahoot for formative assessment. Teachers' qualitative responses indicated that Kahoot technology made assessment easier and facilitated their speed of assessing the learners learning through automated marking and reports. Furthermore, the qualitative results indicated that Kahoot significantly increases learner motivation and participation, makes assessment easier, and makes teachers effective with respect to the PU factor. Regarding the PEU factor, the qualitative data analyses indicated teachers' agreement over common answers regarding the PEU of Kahoot in learner assessment.

The qualitative data analyses show that Kahoot made formative assessment more flexible for teachers and enabled them to undertake assessment ubiquitously in the school. Therefore, the qualitative data analysis results positively support the results of the quantitative data analysis pertaining to teachers' attitudes towards using Kahoot. Furthermore, it is important to note that contemporary teachers are more exposed to technology; thus easy for them to adopt and appreciate technology game-based education compared to traditional ways of assessment. For instance, most teachers use their cell phones to surf the internet. Nowadays, most teachers use social media like Facebook, Twitter and Zoom cloud meetings for communication, education and entertainment.

Along the same lines, Licorish et al. (2018) and Arif (2019) argue that Kahoot plays a significant role in teachers' daily lives since most teachers nowadays are exposed to the

ubiquitous influence and other modern technologies. The connection between modern teachers and technology is strong as technological tools are used on a daily basis by teachers, which then help teachers formulate attitudes towards technology use in the classroom. This finding is in line with research conducted by Eickelmann and Vennemann in 2017, who found that the use of technology in instructional settings in schools is influenced by access, professional development and technical support. This finding further supports earlier studies indicating that perceived ease of use and perceived usefulness tend to be the factors that can influence the attitudes of users toward using an e-learning technology in equal measure for different user types and types of e-learning technology settings (Moreno et al., 2017; Chang et al., 2017; Granić & Marangunić, 2019). Thus the results show that teachers with negative attitudes towards Kahoot will not use it in their classroom. A growing literature by Van Raaij and Schepers, 2008; Jeng and Tzeng, 2012; Lai, 2017 also found that attitude toward using computers did not have a significant effect on the intention to use, and, as stated, some technology acceptance models such as TAM2 omit the factor of attitude. One possible reason for this finding is that the participants in the Fourth Industrial Revolution era could access various online content and communication platforms like Facebook, Twitter, WhatsApp and YouTube. This is consistent with the findings of Wang (2009), who found that the rapid development of emerging technologies has resulted in the availability of a number of information and communication technologies (ICT) tools. Teachers must have the competency to choose and integrate proper tools into teaching and learning.

6.2.2 The analysis of research question 2

What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as a formative assessment technology?

One of the most factors identified by participants as enabling the use of Kahoot as a formative assessment technology was the provision of financial support for schools to implement the use of technology in the classroom. A study conducted in 2016 by Muhametjanova and Çağıltay found that allocating more budget to ICT in the school enables the use of ICT for formative assessment. According to Rahim Sajid (2013), possible enablers include providing monetary and technical support to schools; and financial support from the government. These sentiments were endorsed by Olivia, who stressed that *"The school must direct a huge chunk of money to ICT use because ICT gadgets like computers, projectors and internet connectivity are very expensive,"* Jerry was for the idea that *"The Ministry of Education must give schools enough money to kick-start the using of technology for assessing the learners."* This finding further

supports contemporary studies indicating that adequate funding for the education sector can be a conduit for technology use in schools (Usman & Madudili, 2020; Hume, 2020). One possible reason for this finding is that few teachers in Swaziland use technology to assess the learners because they need technical support, which can be costly. Another possible interpretation is that some school principals support the use of technology in the classroom but lack the technological knowledge, that is, the Fluency of Information Technology (Koehler & Mishra, 2009). Thus, the teachers have understood the value of Kahoot (PU) hence using it to assess the learners.

Another critical enabler that this study found in using Kahoot as an assessment technology is the provision of technical training for teachers. A study carried out in Turkey by Muhametjanova and Çağıltay (2016) found that technical training on ICT should be improved in quality and quantity. During the data generation and analysis stage, technical training for teachers was identified as an enabler for using Kahoot as a formative assessment technology in the classroom. As mentioned in the literature, offering technical training for teachers is a possible enabler for ICT integration in the classroom (Goktas, Yildirim & Yildirim, 2009). Though a majority of the teachers were technology-savvy, they lacked the expertise to use Kahoot in the classroom. For example, Josh, Glenda, Olivia and Jerry were of the opinion that, "*A majority of teachers are not using Kahoot in their classrooms because they lack proper practical training."* But Jabu held a slightly different view: *"What I can say is that as teachers, we do need technical training to be at par with the different needs of the learners in the twenty-first century. But the issue here is that most teachers have a negative attitude towards being workshopped; they are stereotyped and fear change."* The result implies that teachers' mindsets must be changed so that they see the value of technical training. A personal interpretation could be that some school inspectors who normally organise technical training for teachers are not welcoming to teachers. Despite the many enabling factors of using Kahoot as a formative assessment technology, this study also found constraining factors which are discussed below.

One of the most factors identified by participants as constraining the use of Kahoot as a formative assessment technology was the lack of high-speed internet connectivity. Many participants endorsed these sentiments; for instance, Jack stated, *"Technical problems in the classroom such as lack of internet connection,"* Winston noted, *"Lack of the periodic maintenance for computers."* Jerry identified *"Frequent breakdowns of the learning management system."* Therefore, Mbodila and Muhandji (2013) identified the non-availability

of electricity and telephony in most developing countries as constraining factors to ICT integration. A study carried out by Savec (2020) on *'The Opportunities and Challenges for ICT in Science Education'* found that teachers are not able to use the technology and recognise the alignment of the technology with subject-matter content, yet do not integrate technology into the teaching and learning of the content. The findings suggest that the participants' technological knowledge (the expertise to use Kahoot as a formative assessment tool) is hindered by the lack of internet in the classroom. One possible explanation for this finding is that mixing the traditional way of assessment with the modern one is new to most teachers. Another possible explanation could be the non-encouragement of the participation of mathematics teachers in ICT training to increase positive beliefs about assessment with ICT. One teacher mentioned a lack of technical support related to teachers not using Kahoot in their classrooms to formatively assess the learners. Therefore, organising workshops for teachers and the school administration on using Kahoot in the classroom.

In addition to network speed and the challenges of the app itself, teachers who want to adopt Kahoot as an assessment tool in a mathematics class should consider the following. The number of questions should be appropriate, as the opinions expressed in this study indicated that 8-10 questions might be too few for a Kahoot activity. Font size should be adjusted in accordance with class size to avoid the problem of learners being seated too far away to see. Additionally, teachers should ensure that each Kahoot question is understandable and that the volume of the background music is not too loud (Chiang, 2020).

Another constraining factor identified by most teachers of using Kahoot as a formative assessment technology was the lack of basic knowledge for using Kahoot in formative assessment. A few teachers stressed that they were inexperienced with using Kahoot to assess the learners. For instance, Jerry identified *"Lack of experience with modern educational technologies."* Other teachers mentioned, *"Keeping up with the tremendous development in new technologies"* (Lindiwe), and Jack believed that *"Difficulty in preparation of the material to be used on Kahoot"* was a constraining factor too. The findings are consistent with studies by Nguyen and Yukawa (2019) and Cowie and Sakui (2015), who illustrated that technology fluency is one of the challenges facing teachers in linking technology and assessment in order to use digital tools for assessment in general. One participant commented that the lack of students' experience in using a computer made the use of Kahoot in class difficult for the teacher. In other words, teachers may be more likely to use technology in class if the learners are techno-savvy. This finding may result from the teachers' Perceived Usefulness of using

Kahoot. That is, the extent to which a teacher believes that using Kahoot will enhance his or her job performance (Sun et al., 2009; Lai, 2017). This finding further supports Zakia's (2019) study, which examined the learning of English. Zakia found that the use of applications as an assessment tool in learning English was more convenient and more comfortable than the paper-based testing because the result of the students could be seen directly when the quiz was finished, so it was a real and transparent assessment. Therefore, to overcome the lack of basic knowledge for using Kahoot in the classroom, the school administration must organise workshops where teachers are trained on Kahoot use.

6.2.3 The analysis of research question 3

How can primary school mathematics teachers make use of Kahoot as a formative assessment technology?

To respond to this question, the researcher examined primary school mathematics teachers' pedagogical and technological experiences or insights in using Kahoot as a formative assessment technology. During the data analysis stage, five themes were identified by the researcher through the use of the TPACK framework, which are discussed below:

The generated data showed that all of the participants agreed that the use of Kahoot in their mathematics classrooms maintained their learners' attention. Seven of the ten teachers stated that Kahoot helped their learners to recall and memorise information. In contrast, three others highlighted that participating in Kahoot quizzes has helped their learners stay focused. For example, *"Kahoot helped me memorise words because I remember the pictures"* (Jack). *"Kahoot kept my learners awake, particularly in the afternoon mathematics classes when the learners are tired"* (Victor). The findings are consistent with studies by Licorish et al. (2018) and Zarzycka-Piskorz (2016), who found that Kahoot triggers positive attention and focus in the classroom. A recent study by Siok et al. (2021) on *'Engaging Students in a Flipped Language Classroom via Kahoot'* found that Kahoot provides a fun and entertaining platform that helps capture and sustain students' attention in class and allows students to share knowledge among friends. The results imply that Kahoot is helping the learners to be focused. The findings are consistent with Pratolo and Lofti's (2021) study on *'Students' Perceptions Towards the Use of Kahoot'*, which found that Kahoot encourages students to pay attention while studying in the classroom. This finding may be the result of the way to respond in Kahoot was new for the learners to attract their attention, so the learners enjoyed it more than the chalk-and-talk methods.

In addition, one of the common technological experiences mentioned by most teachers was that using Kahoot as a formative assessment technology increases learner interaction and engagement. The generated data showed that Kahoot increased learners' opportunities for interaction with peers and instructors and facilitated learners' deep engagement with content materials. All of the teachers reported that Kahoot encouraged active class engagement, and seven teachers mentioned that Kahoot improved the collaborative skills of their learners. For instance, Winston stated, "The learners are enthusiastic about collaborating with their classmates to answer questions on the Kahoot game and seeing their names *displayed on the scoreboard."* The findings are consistent with Bicen and Kocakoyun's (2018) study on 'Perceptions of Students for Gamification', who found that Kahoot allows players to use nicknames, which encourages wider participation. One possible explanation for this finding is the notion that Kahoot generates cooperation among the players. Jones et al. (2019) argue that student response systems like Kahoot promote student engagement in large lecture halls at the collegiate level, ultimately stimulating active learning rather than passive learning in a teacher-centric environment. This finding further supports recent studies indicating that Kahoot makes learning more interactive and engaging (Holbrey, 2020; Baszuk & Heath, 2020; Chiang, 2020; Dianati et al., 2020).

Another technological experience mentioned by the teachers was that using Kahoot as a formative assessment technology elevates motivation and competition among the learners. Motivation is related to students' attitude, desire, interest, curiosity, and the efforts they show while participating in Kahoot. Research indicates that learning in the form of gamification, such as Kahoot, can elevate an individual's motivation compared with the traditional classroom setting (Arif et al., 2019). Sabandar et al. (2018) also agree that Kahoot is an effective media to motivate and engage learners in the classroom. All of the teachers (N=10) believed that Kahoot brought friendly competition to the classroom, which improved their motivation. These findings are consistent with Wang and Tahir (2020), who found that the goal of Kahoot is to increase engagement, motivation, enjoyment, and concentration to improve learning performance and classroom dynamics. For example, *"The learners are excited and motivated when they see their names suddenly excelling in the leader-board"* (Jack). The results imply that Kahoot elevates the motivation of the learners as compared to the traditional classroom setting. One possible explanation for this finding is that Kahoot allows the inclusion of images and videos that are more attractive to the players. However, the fact that a Kahoot-driven classroom can be turned into a competitive gaming arena is likely to make students concerned

more about winning the game than absorbing the answers to the questions raised (Tran et al., 2019; Petner Jr, 2018).

Another technological experience mentioned by the teachers was that using Kahoot as a formative assessment technology greatly improves learning and knowledge retention in the learners. Most teachers perceived Kahoot to enhance the learning performance of the learners. These findings are in accordance with findings reported by Arif et al. (2019), Ting, Lam and Shroff (2019), who found that Kahoot helps the learners to relate to lectures and lecture notes successfully, put more effort into revising lessons, recalling important points of a particular topic more enjoyably, and discover new information, improve learners' retention power, and monitor their progress. For example, Olivia mentioned that *"Kahoot helps my mathematics learners study and remember correct answers."* One possible interpretation for the findings is that Kahoot has enhanced features of inserting videos and pictures during the quiz to get insights into the students' knowledge, learning, and distinct learning styles. Recent studies by Holbrey, 2020; Alawadhi and Abu-Ayyash, 2021 also found that Kahoot assists learners in remembering information. A study conducted by Tan Ai Lin, Ganapathy and Kaur (2018) found that using Kahoot feels like a flash revision that makes learners remember the lecture more, winning or losing the quiz. The second interpretation of the findings is that Kahoot has a plethora of features that support players' knowledge retention; for instance, players can attain instant feedback, and it is differentiated from the traditional paper quiz; students take part in this quiz to answer the questions. This aligns with the learning by doing theory expounded by John Dewey in 1959.

Lastly, the study findings revealed that some pedagogical advantages of using Kahoot as a formative assessment technology as experienced by most teachers is providing the learners with fun and enjoyment. For example, most teachers acknowledged that fun is one element found in Game-based Student Response System (GSRS). The students enjoyed and were motivated when assessed using Kahoot because they competed with their friends to become a winner, which created classroom competition (Zakia, 2019; Wang & Tahir, 2020; Pratolo & Lofti, 2021). Playing Kahoot at the end of the class whips up the learners' enthusiasm to learn. It adds a fun element to the lesson (Aktekin et al., 2018). For example, *"There is a lot of positive energy in the classroom when the learners participate in Kahoot"* (Nomuzi). *"Mathematics classes are more fun with Kahoot. Kahoot created a happy atmosphere in the classroom"* (Glenda). One possible explanation for this finding is the notion that Kahoot is a visualised and unique type of game which can assist the learners in making associations between pieces of

information. Another possible explanation is that quiz and jumble Kahoots show the scoreboard after each question; this creates competition among the learners. This finding is further substantiated by Siok et al. (2021), who found that Kahoot's interactive and competitive feature provides a fun and entertaining platform that helps capture and sustain students' attention in class and allows students to share knowledge among friends.

6.3 Chapter summary

In this chapter, the researcher discussed the findings that emerged from the data. The findings of this study were compared to the literature reviewed in chapter two. In discussing the key elements and the recurring themes that emerged from the data, the researcher has responded to the research questions: (1) What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology? (2) What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as an assessment technology? (3) How can primary school mathematics teachers make use of Kahoot as an assessment technology? In the next and final chapter, the researcher presents the study's main conclusions, reflects on its overall value, and closes with some suggestions for further areas that might be researched.

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The previous chapter discussed the findings that emerged from the data. In this chapter, the researcher reflects on the exploratory case study. In this last chapter, the researcher begins by presenting: (a) summary of key research findings, (b) limitations of the study, (c) conclusion, (d) recommendations for practice, and lastly, (e) recommendations for further studies.

7.2 Summary of key research findings

The overarching objective of this study is to explore how primary school mathematics teachers make use of Kahoot as a formative assessment tool. To achieve this objective, the following research questions were asked:

1. What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?
2. What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as a formative assessment technology?
3. How can primary school mathematics teachers make use of Kahoot as a formative assessment technology?

The study followed a mixed methods approach that was largely qualitative with a thin quantitative strand. The choice of this research design was to merge quantitative and qualitative data to develop a complete understanding of the research problem presented in chapter one (Creswell et al., 2011). The study adopted the tenets of the interpretive paradigm to understand the research problem since the study sought the participants' perceptions regarding the use of Kahoot as a formative assessment tool in mathematics lessons. Therefore, a purposive sampling method was used to choose all the ten primary school mathematics teachers in the school because of their relevant knowledge, interest, and experience in relation to the case (Rule & John, 2011). The criteria for selecting the participants and the site were justified. Data were generated using the following research instruments: structured questionnaires, observations, workshops, focus group interviews, and reflective journals. The theoretical framework that underpinned this study was a combination of Davis' (1989) Technology Acceptance Model (TAM) together with Mishra and Koehler's (2006) Technological Pedagogical Content

Knowledge (TPACK) framework. The TK and TPCK constructs of the TPACK framework were used to interpret the study findings for research questions two and three. For research question one, the researcher used the two constructs of the TAM: PU and PEU. The study also adopted the TPACK-In-Action model framed within the TPACK framework and advocates a learning-by-doing approach. Reasons for using the constructs of the different models were explained and justified. Lastly, data were analysed quantitatively using descriptive statistics and qualitatively, allowing themes to emerge from the raw data. The following is an in-depth discussion on the summary of key research findings regarding the three research questions.

The study aimed to add to the body of knowledge on how primary school mathematics teachers make use of Kahoot as a formative assessment tool within a rural primary school in the Shiselweni Region in Swaziland. The following questions were answered:

7.2.1 What are the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology?

This question explored the perceptions of primary school mathematics teachers on the use of Kahoot as an assessment technology. It was answered by analysing the structured questionnaire responses (***see, Appendix 6***). The findings on teachers' perception of technology use in assessment were encouraging. The analysis of the quantitative results of question one indicates that the perceptions and attitudes of primary school mathematics teachers towards using Kahoot generally appear to be positive. The actual number of responses selected for strongly agree was 75 out of 90 for PEU; and 90 out of 110 for PU. Therefore, the general attitude for PU and PEU was 83%. As for the qualitative results revealed by the workshops, observations, journal reflections and focus group interviews with the teachers, it was found that they support the quantitative results from the structured questionnaires. The generated data revealed that all the participants (N=10) found Kahoot useful and perceived it easy to use.

7.2.2 What are the primary school mathematics teachers' enabling and constraining factors of using Kahoot as a formative assessment technology?

The study explored the primary school mathematics teachers' enabling and constraining factors of using Kahoot as an assessment technology to answer this research question. The findings were encouraging; one of the factors identified by participants as enabling the use of Kahoot as a formative assessment technology was the provision of financial support for schools to implement the use of technology in the classroom. The study also found that the provision of technical training for teachers is another enabler for Kahoot use in the classroom. In contrast,

the study's constraining factors of using Kahoot as a formative assessment technology were lack of high-speed internet connectivity and lack of basic technological knowledge for using Kahoot in formative assessment. Lastly, the study has provided the teachers and the researcher with technological knowledge on the use of Kahoot as a formative assessment technology in mathematics lessons.

7.2.3 What are primary school mathematics teachers' pedagogical and technological experiences in using Kahoot as a formative assessment technology?

When examining primary school mathematics teachers' pedagogical and technological experiences in using Kahoot as a formative assessment technology, teachers revealed significant benefits of using Kahoot as an assessment technology in the classroom. During the data analysis stage, five themes were identified by the researcher. First, the findings showed that all of the participants seem to agree that the use of Kahoot in their mathematics classrooms maintains the attention and focus of the learner. Second, Kahoot increases interaction and engagement among the learners. Third, Kahoot elevates motivation and competition among the learners. Fourth, Kahoot improves learning and knowledge retention in the learners. Lastly, Kahoot provides the learners with fun and enjoyment. Despite the benefits of using Kahoot as a formative assessment technology, the study also found that managing a Kahoot-driven classroom is difficult for the teacher because of the noise generated, and being ranked on performance does not appeal to all learners.

7.3 Limitations of the study

There are many limitations associated with this study that restrict the claims that can be made and suggest future directions for research.

- The sample size was adequate: ten primary school mathematics teachers. The exploratory case study findings cannot be generalised to represent all mathematics teachers in the Shiselweni region or the whole of Swaziland because participants were purposively selected (limited to the ten research participants).

- The COVID-19 pandemic slowed down the process of data generation for this study. At times, the Swaziland Ministry of Education suspended classes due to COVID-19 suspect cases. Participants self-isolated while waiting for their results. Furthermore, learners were not supposed to be more than twenty per class; this meant that the learners came to school in shifts: grades 1 – 4 came to school from Monday to Wednesday and

grades 5 – 7 came on Thursday and Friday. Therefore, classroom observations were affected.

- The Swaziland 2021 political uprisings, which erupted in June, affected the research. The Prime Minister suspended all classes for three months for the safety of the learners and teachers. Most learners in different schools were rioting and burning school furniture. Schools were not conducive to learning. Therefore, the researcher resumed the data analysis process after the political atmosphere was calm.

- Moreover, this study was conducted in a rural school context. Therefore, the findings of this study cannot be generalised to urban schools.

7.4 Conclusion

This study explored how primary school mathematics teachers make use of Kahoot as a formative assessment tool. The study adopted the interpretive paradigm tenets and a case study as a research style. The methods used to generate data were structured questionnaires, workshops, observations, focus group interviews, and reflective journals. The study was conducted at Central Academy (a pseudonym), a rural primary school in the Shiselweni Region in Swaziland. In this study, the ten primary school mathematics teachers who were participants were chosen using purposive sampling. The study's findings showed that the use of Kahoot in the classroom improves the formative assessment of mathematics. The results led the research to conclude that using Kahoot as a formative assessment technology creates efficiency in mathematics assessment. The analyses further demonstrated that Kahoot increases learner motivation, engagement, attention, enjoyment, and knowledge retention.

7.5 Recommendations for practice

The researcher wishes to make the following recommendations based on the study findings.

- Schools need to have computer laboratories or technologies in classrooms with strong internet connectivity to pave the way for using digital technologies such as Kahoot in the classroom.

- Administrative support is needed for the successful integration of ICT into teaching and learning. Education policymakers need to provide necessary conditions, such as ICT policies, incentives, and resources. Furthermore, the number of technological gadgets should be increased and their use encouraged within the classroom.

- Teachers need adequate training on using ICT for teaching and learning to acquire the necessary knowledge and skills to use technology in their classrooms. The training should not be a once-off training but a continuous process. The training should not be limited to using technology in the classroom but should show teachers how to use it to improve their teaching quality and effectiveness. The training should be well structured and develop the teachers' TPCK.

- More attention should be given to the ICT services and tools generally provided in schools, as well as the lack of maintenance, ICT tools and facilities, and poor Internet services. These factors must be seriously considered to support teachers in using technology in the classroom and develop a positive attitude toward technology.

- Teachers need encouragement to improve their technological skills by attending relevant conferences and workshops, which will help them develop their teaching proficiency.

- Instructional technology specialists need to provide professional development to teachers on the Technological Pedagogical and Content Knowledge (TPACK) framework to improve their ability to integrate technology in the classroom. TPACK gives teachers a new framework for integrating technology in education and how they can structure their classrooms to provide the best educational experience for students while incorporating technology.

- Technology literacy in schools should be viewed with the same importance as reading, writing, and arithmetic to encourage teachers' to become more technology literate, thus improving their ability to integrate technology into their lessons.

7.6 Recommendations for further studies

As mentioned earlier on (literature review section), the researcher hopes the idea of including technological games or gamification approach in teaching and learning can be adopted by other teachers as it can allow the identification of learners' weaknesses, which will enable teachers to tailor instruction according to individual needs of the learners. However, there are many directions that future studies can take.

- The use of Kahoot is a relatively new concept in education. Its use was adopted in developed countries to address many issues teachers face, such as giving feedback to learners on time during formative assessments and maintaining learners' attention and

focus. However, research on its effectiveness in learner achievement is in its infancy. Understanding the impact of Kahoot on learner achievement at the primary school level is critical to informing the adoption of Kahoot. This study only explored using Kahoot for formative assessment from the teachers' perspective and did not investigate learners' experiences using Kahoot. Thus it would be valuable for future research to focus on learners' experiences of using Kahoot in mathematics assessment.

- In addition, future studies could explore the use of Kahoot in different subject areas. This study only focused on mathematics; thus, it is recommended that future research be conducted to understand how teachers can use Kahoot in other subjects.
- Further investigation could focus on the use of Kahoot as a formative assessment technology in resource-constrained schooling context using multiple cases, as this study employed a single case.
- In addition, this research was underpinned by the combination of TAM and TPACK framework. Future research could use Venkatesh et al. (2003) theoretical model of Unified Theory of Acceptance and Use of Technology (UTAUT), which suggests that the actual use of technology is determined by behavioural intention. Validating and challenging theoretical assumptions could help future researchers build new knowledge and fill in knowledge gaps.

In conclusion, several questions were raised by this study that can be answered by future studies using other methodologies. For instance, it will be valuable to adopt a comparative research design where the research will detect similarities or differences between urban and rural schools on the use of Kahoot in the assessment of learner learning.

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LIST OF APPENDICES

Appendix 1 – Permission seeking letter to the school principal for authorisation

The Principal

Central Academy

P O Box 37

Shiselweni

Dear Madam

Request for permission to conduct educational research in the school

My name is Thando Simelane**,** a Master of Education student registered at Rhodes University in South Africa, student number 18S4928. I am conducting a research study entitled: Exploring how primary school mathematics teachers use Kahoot as a formative assessment tool: a case study. Therefore, I am requesting access to your school to carry out a study regarding the topic mentioned above. The study will involve the mathematics teachers. I plan to conduct a workshop where I will train primary school mathematics teachers on the use of Kahoot as an assessment tool, and they will all be expected to write journals after a series of lessons which will form part of the data. Informed consent will be requested from the Regional Education Officer and mathematics teachers. Participants will not get any incentives and rewards for participating in the study.

You are assured that the study will not in any way interrupt the normal running of the school as the participants will be engaged outside the normal teaching time to protect teaching time. The involvement of the participants in this research study is completely voluntary, and they can withdraw at any time without prejudice. The data collected from this research study will be published as the Rhodes University full thesis. The data may also be published in articles emanating from the thesis. In addition, the study may benefit the participating teachers as far as the assessment of mathematics is concerned. The identity of each participant and their views or contributions will be treated with a high degree of anonymity. Extra support and activities such as worksheets, video lessons and other relevant teaching materials will be available for all those teachers who do not wish to be part of this research. They will not be disadvantaged in any way.

This research has been approved by the Rhodes University Ethical Standards Committee and the Education Department Higher Degrees Committee. During the research, any concerns may be directed to the Rhodes University ethics committee, ethics-committee@ru.ac.za

Please feel free to contact me at (+268) 76139705, simelanet64@gmail.com or my supervisor, Dr Clement Simuja c.simuja@ru.ac.za

I thank you for taking the time to read this letter. Your permission to conduct this study at your school will be highly appreciated.

Yours sincerely,

_____

Simelane Thando

Approved by:

_____ _____ _____

Print your name and title here Date Signature

Appendix 2 – Permission seeking letter to the Regional Education Officer (REO) for authorisation

The Regional Education Officer

Ministry of Education and Training

P O Box 39

Mbabane

Dear Madam

Request for permission to conduct educational research in the school

My name is Thando Simelane**,** a Master of Education student registered at Rhodes University in South Africa, student number 18S4928. I am conducting a research study entitled: Exploring how primary school mathematics teachers use Kahoot as a formative assessment tool: a case study. Therefore, I am requesting access to your school to carry out a study regarding the topic mentioned above. The study will involve ten mathematics teachers. I plan to conduct a workshop before the study commences, where I will train primary school mathematics teachers on the use of Kahoot as an assessment tool. They will all be expected to write journals after a series of lessons that form part of the data. Informed consent will be requested from the school principal and mathematics teachers. Participants will not get any incentives and rewards for participating in the study.

You are assured that the study will not in any way interrupt the normal running of the school as the participants will be engaged outside the normal teaching time to protect teaching time. The involvement of the participants in this research study is completely voluntary, and they can withdraw at any time without prejudice. The data collected from this research study will be published as the Rhodes University full thesis. In addition, the study may benefit the participating teachers as far as the assessment of mathematics is concerned. The identity of each participant and their views or contributions will be treated with a high degree of anonymity. Extra support and activities such as worksheets, video lessons and other relevant teaching materials will be available for all those teachers who do not wish to be part of this research. They will not be disadvantaged in any way.

This research has been approved by the Rhodes University Ethical Standards Committee and the Education Department Higher Degrees Committee. During the research, any concerns may be directed to the Rhodes University ethics committee, ethics-committee@ru.ac.za

Please feel free to contact me at (+268) 76139705, simelanet64@gmail.com or my supervisor, Dr Clement Simuja c.simuja@ru.ac.za

I thank you for taking the time to read this letter. Your permission to conduct this study will be highly appreciated.

Yours sincerely,

_____

Simelane Thando

Approved by:

_____	_____	_____
Print your name and title here	Date	Signature

Appendix 3 – Teacher participant's assent form

Informed consent declaration

(Teacher participation)

Research title: Exploring how primary school mathematics teachers use Kahoot as a formative assessment tool: a case study

Researcher's name: Thando Simelane

Name of participant: _____

Please tick (√) in the box of your choice.

1. Has the researcher explained what he wants you to do and what he will be doing?

   YES NO

2. Has the researcher explained why he wants you to participate in this study?

   YES NO

3. Do you understand the purpose of the research?

   YES NO

4. Do you know that anything bad or good might happen to you during the research?

   YES NO

5. Do you know that your name will be kept a secret from other people?

   YES NO

6. Did you ask the researcher any questions about the research?

   YES NO

7. Has the researcher answered all your questions?

   YES NO

8. Are you aware that you cannot participate in this study if you like?

   YES NO

9. Are you aware that you can stop participating in his study if you like, and nothing will happen to you?

   YES NO

10. Do you know whom to talk to if you want to ask something about this study?

YES NO

11. Has anyone forced you to be part of this study?

YES NO

12. Are you willing to take part in this study?

YES NO

_____ _____

(Signature of teacher) Date

Appendix 4 – Informed consent

I understand that being a participant means I will be observed while teaching mathematics and interviewed (with recordings)

- I will be the participant in the topic mentioned above
- I am willing to be interviewed and make time for it
- the information provided will be used only in the research project
- I am also aware that the information provided by me will be strictly confidential, and the findings will be reviewed in the research thesis
- I am aware that my identity in this study will be protected by the code of ethics stipulated by Rhodes University
- I am aware that having taken note of the above information, I freely volunteer to participate in the research process and acknowledge that I have not been forced to do so.

Declaration

I …… (Full name and surname of participant) hereby confirm that I understand the contents of this letter and the nature of the research project. I consent to participate in the research project.

Signature of participant …….. Date ……

Yours faithfully

Simelane Thando

Master of Education in ICT

Appendix 5 – Observational tool

Observation Schedule Form

Current profession…… Position……..……..

Age …… Gender…….

Years of teaching experience…….. Grades…….

Subjects……
……..

Place of employment ……. Region……..……

Teacher's Technological Knowledge (TK)	
Measure	**Notes**
Teacher ability to use Kahoot easily	
Teacher able to resolve his or her own technical problems	
Teacher plays around with Kahoot (upload different media like videos, pictures, web links, etc.)	
Teacher demonstrates expertise in using Kahoot?	
Teacher selects and makes use of appropriate media to assess the learners using Kahoot	
Teacher's Technological Pedagogical Content Knowledge (TPCK)	
Measure	**Notes**
Teacher can find and evaluate resources needed to use Kahoot as an assessment tool	

Teacher demonstrates knowledge of how to use Kahoot to assess the learners	
Teacher demonstrate knowledge of how technologies can be used for assessing a particular content	
Teacher demonstrates to the learners how to play the Kahoot game	
Teacher's ability to use technology for assessing a particular content	

Observer's name_____ Date _____
Signature_____

Teacher's name_____ Date_____

Signature _____

Appendix 6 – Structured questionnaire

Date: _____

Phone: _____

Email: _____

Introduction

This is an M Ed research questionnaire designed to obtain your views on the **use of Kahoot for formative assessment at your school**. Kindly be open and free as possible. Be assured that absolute confidentiality will be adhered to, and under no circumstances will your details be revealed to a third party. Please answer all questions to the best of your knowledge. Your responses will be kept completely confidential. Thank you for your participation.

Instruction

Read each question carefully. The questions are followed by possible answers. There are indications for each question you read on the number of possible choices. Tick in the appropriate space next to the answer of your choice. Kindly respond to **ALL QUESTIONS** to the best of your ability. Your honesty will be appreciated**.**

Section A: Background information

Indicate by ticking in the spaces provided.

1. Identify your gender

Male ……

Female …….

2. Indicate the grade your teaching

   Grade 1 ……
   Grade 2 ……
   Grade 3 ……
   Grade 4 ……
   Grade 5 ……
   Grade 6 ……
   Grade 7 ……

3. Indicate the level of your study

   Primary Teachers Diploma (PTD) ……
   Bachelor's degree (BED) …….
   Master's degree (MED)……
   Other (specify)
   …….

4. How do you rate your experience in using Kahoot?

   Excellent ……..
   Very good …….
   Good ……..
   Fair ……..
   Poor …….

5. How many years of work experience do you have in teaching mathematics?
   ……

Section B: Perception and attitude towards Kahoot

No.	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Using Kahoot makes assessment much easier					
2	Using Kahoot increases learner motivation and participation					

3	Using Kahoot allows me to create quizzes within a few minutes					
4	Using Kahoot allows me to work easily with other learners outside the lessons					
5	Using Kahoot makes me an effective teacher					
6	Using Kahoot enables me to accomplish formative assessments more quickly					
7	Kahoot is useful as an assessment tool; it has the feature of importing questions from the internet					
8	Using Kahoot allows me to accomplish more than does using traditional tools					
9	Kahoot provide access to the visibility of reports about the progress level of the class					
10	Kahoot allows me to produce more in the time I have					
11	Overall, I find Kahoot useful for my formative assessment					
12	Kahoot is generally easy to use in my subject					
13	I find it easy to share reports with the other teachers and the school administration.					
14	I find it easy to manage my subject files using Kahoot					
15	I use Kahoot because it allows me to do assessments wherever I need					
16	I find it easy to get Kahoot to do what I want it to do					
17	It is easy for me to insert drawings in the iOS app or add YouTube videos to questions					
18	I find the use of Kahoot clear and easy to understand					
19	I find it easy to download reports from the spreadsheet					
20	Overall, I perceive Kahoot technology easy to use					

Appendix 7 – Reflections

Journal Book

Name _____ Subject: Mathematics

Date _____ Code _____

Instruction: Please reflect on the following points

In today's lesson, Kahoot helped me to design formative assessment by …

When using Kahoot as a formative assessment tool, I felt that I benefited the most from …
Comment on how Kahoot helped you draw group and individual reports of students' performance.
In today's lesson, I think Kahoot hindered the assessment of the learners by …
Use the space below to write anything you want to say about the lesson.

Appendix 8 – Focus group interview questions

Exploring how primary mathematics teachers use Kahoot as a formative assessment tool: a case study

Questions
What makes you excited to use technology in class? (ice breaker)

What are your experiences with the use of Kahoot as a formative assessment tool in class?
When using Kahoot to formatively assess the learners, which areas did learners enjoy the most and did not enjoy?
From your experience of using Kahoot as a formative assessment tool, what factors do you think a) Has it motivated you as a teacher to make the best use of Kahoot as formative assessment technology? b) Has it constrained you as a teacher to use Kahoot in class and formative assessment of learners? c) Has allowed /enabled you to experience new attributes of using Kahoot as a formative assessment technology?
Why would you prefer using Kahoot in assessing learners' understanding of mathematical concepts? Give a reason.
In your opinion, is Kahoot effective in assessing learners' understanding of mathematical concepts? Give a reason.
Do you think Kahoot should be used to assess the learners in mathematics? Give a reason.
After participating in this study, is there any change in your perceived usefulness of the use of Kahoot/ technology-based games in formative assessment in mathematics lessons?
Is there any information you would like to share with me related to this interview that I have not captured in my questions?

Appendix 9 – Ethics Clearance Letter

RHODES UNIVERSITY
Where leaders learn

Rhodes University, Education Faculty
Research Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
Tel: +27 (0) 46 603 8393
Fax: +27 (0) 46 603 8028
email: e.rosenberg@ru.ac.za

https://www.ru.ac.za/researchgateway/ethics/

07/05/2021

Dr Clement Simuja

Education Department

C.Simuja@ru.ac.za

Dear Dr Clement Simuja and Mr Thando Simelane,

Re: Exploring how primary school mathematics teachers make use of Kahoot! as a formative assessment tool: a case study

APPLICATION NUMBER: 2021-2681-6008

This letter confirms that your research ethics application has been reviewed and **APPROVED** by the Education Faculty Research Ethics Committee (EF-REC). Your permission letters from a school principal and Regional Education Officer have been received and you are free to proceed with your study.

Approval is granted for 1 year. An annual progress report is required in order to renew approval for an additional period. You will receive an email notifying you when the progress report is due.

Should any substantive change(s) be made during the research process, that may have ethical implications, you should notify the Education Faculty REC Chair via email. This includes changes in investigators. The REC Chair will advise as to whether a new application is necessary.

Do keep this clearance letter secure and accessible throughout your study and after its completion. It will be needed when a thesis is examined and when publications are submitted to journals.

Please also submit a brief report to the REC Chair on the completion of the research. This can be done via email. The purpose of this report is to indicate whether the research was conducted successfully and whether any ethics-related matters arose that the committee should be aware of, in order to guide future studies. Sincerely,

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee