Gamification technology in teaching: Exploring how Mathematics Teachers make use of Kahoot! Gamification to facilitate learning of Probability in classrooms.

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By

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Declaration

I, Ayanda Mbete, hereby declare that the contents in this thesis **Gamification technology in teaching: Exploring how teachers make use of Kahoot! gamification to facilitate learning of Probability in their classrooms**, constitute my own independent work and has not been submitted by me for a degree to any other university. All the ideas used from other writers have been acknowledged and referenced.

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August 2022

Ayanda Mbete

Date

Abstract

This study seeks to examine the use of Kahoot! as a gamification technology in practice with Grade six teachers to explore its use in supporting the learning of Probability in Mathematics in rural primary schools. Purposive sampling was adopted wherein nine Grade six mathematics teachers from four rural primary schools in Amathole East district were selected as participants of the study. In addition, to inform this qualitative case study, an interpretive paradigm was adopted. Data was collected using semi-questionnaires, semi-structured interviews, non-participant observations, workshop discussions and reflective journals. The TPACK by Mishra & Koehler (2009) and Vygotsky's (1978) socio-cultural theory were employed as the lenses through which all the proceedings of the study were based. The key findings indicate that integrating Kahoot! gamification technology, in the 'Probability' lesson, has positive consequences such as bringing fun into the classroom, enhancing learner participation, prompt feedback and offering a learner-driven approach to learning as opposed to the conventional teaching strategies.

The findings also revealed that enabling and constraining factors are associated with using Kahoot! in teaching: the ICT infrastructure, teachers' competency levels and the environment in which teaching and learning occurs. This study concluded that the use of Kahoot enhances the learning of probability in rural under-resourced primary schools. This study recommended the integration of Kahoot gamification into the mathematics curriculum.

Key words: Kahoot! Gamification, Technology, Probability, Mathematics, rural primary schools, teachers, teaching, learning, classrooms, Technological Pedagogical and Technology Knowledge (TPACK), Socio-Cultural-Theory.

Dedication

This piece of work is dedicated in memory of my late parents, who had been inspirational and supportive in my life. They played a tremendous role in instilling the quest for knowledge in me.

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List of Acronyms used in the study

ACE : Advanced Certificate in Education

B.Ed.: Bachelor of Education.

CAPS: Curriculum and Assessment Policy Statement

CK : Content Knowledge

EOU : Ease of Usefulness

ICT : Information and Technological Knowledge

Math: Mathematics

MKO: More Knowledgeable Others

NSC : National Senior Certificate

PCK : Pedagogical Content Knowledge

PEOU: Perceived Ease of Usefulness

PK : Pedagogical Knowledge

SAMR: Substitution, Augmentation, Modification, and Redefinition

SCT : Socio-Cultural Theory

TCK : Technological Content Knowledge

TIMSS: Trends in International Mathematics and Science Study

TK : Technological Knowledge

TPACK: Technological Pedagogical and Content Knowledge

TPK : Technological Pedagogical Knowledge

Chapter One

1.1. Introduction

The twenty-first century (21st) era has necessitated a drastic shift in the teaching and learning landscape. The 21st century marks a period from 1st January 2001 until 31st December 2100 (Davis, 2021). This era is characterized by technological advancement in all spheres of life. In the education sector, the 21st-century era connotes the core competencies that the teachers and learners need to nurture in order to thrive in today's world: collaboration, digital literacy, problem-solving skills and critical thinking inter-alia (Sabandar, Supit, & Suryana, 2018). Modern learners are much engaged with technology, and in education, game-based learning is one of the strategies that can be employed to enhance learning; hence this study explores the use of Kahoot! Gamification technology to support the teaching and learning of one of the mathematics topics. In this study, "technology" and "Information and Communication Technology" (ICT) are used interchangeably to mean the same thing.

This chapter introduces a study about the use of gamification technology in the teaching and learning of probability which is one of the topics in mathematics in South Africa. The focus of this study is on the rural primary schools that are in possession of the 6th Grade. This introductory chapter provides the contextual background to the study, the problem statement, the purpose and significance of the study, and the goals of the research, followed by the research questions addressed in this study. Lastly, the chapter concludes by outlining the structure of the study.

1.2. Background Context of the Study

The context of the study will be discussed at the Macro, which is the international level and Micro level, which is the local context.

1.2.1. Macro Context

Mathematics is one of the most important and critical subjects worldwide. It cuts across primary through to secondary education and is compulsory in some countries, including South

Africa. Mathematics is of great value to any country's economy, and life could be so unpredictable without it; this is the reason why I align myself with Umameh (2011) as he articulates that "Mathematics is intimately connected to daily life and everybody's life-long planning... and that human life cannot function effectively without it" (p. 5). As human beings, we use mathematical applications in our daily life, starting from cooking, measuring the water we drink, sports, driving, sewing, and budgeting inter-alia.

According to the report by Trends in International Mathematics and Science Study (TIMMS), few countries record satisfactory performance in the fourth and the eighth grade. This reveals that mathematics in many countries is generally performed below the benchmark (Mullis et al., 2016). Within these few performing countries, most of them are based in East Asia, including Singapore, Hong Kong, Korea, Chinese Taipei, and Japan. Similarly, Mullis et al. (2016) highlight that these countries took many initiatives to improve mathematics teaching and learning. The sharp improvement in students' performance in mathematics in some countries has been attributed to the integration of technology in the teaching and learning of mathematics (Sara Hennessy et al., 2010). Many governments across the world have been putting forward ICT initiatives in both mathematics-performing and non-mathematics-performing schools (Kabutey, 2016). This supports the notion by Tata Umar Sa'd (2014), who alludes that in Nigeria, as in other countries, mathematics is given much attention in curriculum and in education-related policies. For example, despite the tremendous attention given to mathematics in Africa, abysmal performance is always noticed in public examinations. Also, poor mathematics performance leads to poor performance in the Science stream (Tata Umar Sa'd, 2014). A recent study in Nigeria by Hammed & Suleiman (2019) reveals that the students' failure in mathematics is attributed to teachers' teaching methods, students' attitudes, and lack of learning resources, among other things. This is the reason why this study is exploring the utilisation of gamification technology to facilitate Mathematics learning.

Also, the COVID-19 pandemic 'synonymously known as corona virus' (Sibeko, 2020, p. 1), which is a deadly virus that has led to the global unprecedented health crisis, has caused a major disruption in the education system. The schools had to drastically lockdown to prevent further transmission through isolation and physical distancing (Giovannella, 2020). This

compels the education sector to develop an alternative approach to teaching and learning where technology integration, both synchronously and asynchronously, has been central in the mitigation of lost contact time. Therefore, the education system requires teachers and learners who are competent enough to meet the demands of the current situation. Consequently, appropriate use of ICT in all subjects, including mathematics, could assist in the curriculum delivery to enhance learner improvement despite the status quo (Hardman, 2020).

1.2.2. Micro context

South Africa is always on the lowest rung of the ladder in international studies for mathematics performance across the Grades, as revealed in TIMSS (Trends in International Mathematics and Science Study) reports in 2015 (Letaba, 2020). Moreover, according to the Amathole East district 2018 and 2019 report on analysis of the question by question of common tasks for the fourth term for Grade six, most learners poorly perform in mathematics, especially the topic of Probability, even though it constitutes fewer marks than other topics. Numerous factors have been identified in the literature to be the causes of mathematics underperformance, and I agree with Karue & Amukova (2013) as they suggest that students' failure in mathematics is attributed to the teaching and learning approaches, among other reasons. I am of the view suggested by Raja & Nagasubramani (2018) that the incorporation of modern and technological teaching and learning methods may positively impact mathematics learning. Similarly, Yaratan & Eyyam (2014) postulate that "when technology is used appropriately in classroom instruction, it has a very positive impact on student achievement or success" (p.32). Traditional teaching approaches in Mathematics have been ineffective and boring as they lack learner motivation and engagement.

During the 2019 SONA (State of the Nation Address) injunction, the South African President, Cyril Ramaposa, announced that the government would provide every school child in South Africa with digital workbooks and textbooks on a tablet device over the next six years and the roll-out will start with schools that were pre- historically most disadvantaged, located in the poorest communities, including multi-grade, multi-phase, farm and rural schools (Africa, 2020). This was a call to accelerate the training of both educators and learners in response to emerging technologies. Furthermore, this was aimed at bridging the digital divide by targeting

previously disadvantaged groups (Education, 2004). Also, some rural primary schools of Amathole East District received learner tablets with internet access through a partnership with the Thabo Mbeki Foundation and Spain called ProFuturo (pro future) project. This is in addition to schools that acquired tablets through the normal Learner Teacher Support Material (LTSM) requisitioning procedure. It is against this context that I felt conducting a study to explore the effectiveness of Kahoot! as a gamification technology in the learning of Probability lessons in mathematics, prioritizing the rural primary schools is viable. In addition, Decheva et al. (2015) posit that "the use of educational games as learning tools is a promising approach, due to the games' abilities to teach and reinforce not only knowledge, but also, problem-solving skills, collaboration, and communication" (p.1). Therefore, it is paramount for teachers to ensure that every learner taught can acquire problem-solving and collaboration skills and be able to communicate with others.

According to Deterding et al. (2020), gamification is defined as "the process of using game thinking and game mechanics to solve problems and engage users" (p.90). Therefore, gamification may mediate learner performance with the appropriate ICT infrastructure and relevant integration of pedagogy and content. This study seeks to explore how teachers incorporate Kahoot! as a gamification technology to facilitate the learning of Probability lessons.

1.3. Problem statement

Mathematics is one of the gateway subjects that are critical for economic growth and development in the Republic of South Africa. Teachers in our country are grappling to find appropriate strategies for teaching mathematics to learners. This is evident as South African learners achieve below 65%, which is the benchmark set by the national office during the National Senior Certificate (NSC) examinations. This abysmal mathematics performance is also manifested in the five-year term performance of the Amathole East district. in the NSC results (DoE examination report, 2017,2018,2019.2020 & 2021). **Table 1** portrays Amathole East mathematics NSC performance trend as compared to the provincial and national performance.

Table 1 : Amathole East Mathematics NSC performance trend

Years	2017	2018	2019	2020	2021
Amathole East	31.5	45.5	36.6	36.6	47.7
Provincial	42.3	45.5	41.8	39.7	46.6
National	51.9	58.0	54.6	53.8	57.6

The table below reveals the national performance of Probability topic as per the question-by-question analysis in the diagnostic reports from 2017-2021.

Table 2: Performance of Probability in NSC examinations

Performance of Probability as per the NSC Diagnostic reports				
2017	**2018**	**2019**	**2020**	**2021**
41%	31%	21%	18%	27%

Probability is the most recurrently underperformed mathematics topic in the NSC examinations, and it shows a decline from 2017 to 2020. In addition, according to the Trends International Mathematics and Science Study (TIMSS) report of 2015, South Africa recorded low performance in Mathematics in Grades 5 and 9, and the worst affected learners are in the no-fee public schools (Letaba, 2020). This is a cause for concern as most Amathole East district schools fall under the no-fee public school category. Furthermore, many learners who perform badly in Mathematics do best in other subjects.

According to the findings of Mabena, Mokgisi and Serole Ramampela (2021) poor performance in mathematics is attributed to the teachers' lack of pedagogical content knowledge in teaching mathematics which was evident when teachers were using teacher-centred methods in which learners listen to the teachers dispensing the information, followed by the question-and-answer approach. Loughran et al., (2011) introduce pedagogical knowledge in mathematics as the ability of a teacher to use his or her knowledge of mathematics in tackling mathematics topics

using the appropriate strategies to deliver mathematics content and topics effectively to enhance successful learning. These findings are in line with Karikari et al., (2020), whose study's results revealed that poor teaching methods, among other factors, contributed to students' poor academic performance in mathematics education.

Literature reveals that teaching mathematics with technology enables educators to act as facilitators during the learning process, thus supporting constructivism as learning becomes student-centred, giving allowance to learners to construct knowledge (Condie & Munro, 2007; Keong et al., 2005). The statement above unveils that even though there may be challenges with the use of technology in the classroom, there might be benefits in integrating technology in the teaching and learning of mathematics.

In searching the literature, the researcher discovered that no studies could be found on the use of gamification technology in the teaching and learning of probability topics in primary schools in South Africa. Therefore, a knowledge gap exists between affordances and hindrances when mediating learning of probability using Kahoot! Gamification technology. Most of the studies in the context of integrating ICT in mathematics education have focused on benefits (Keong, Horani, & Daniel, 2005, Khambari, Luan, & Ayub, 2010, Wassie & Zergaw, 2019) and challenges of using ICTs for teaching and learning (Mathevula & Uwizeyimana, 2014, Mokotjo & Mokhele, 2021) as well as teachers' perceptions and attitudes on ICT integration in the classrooms (Nkula & Krauss, 2014, Bas, Kubiatko, & Sünbül, 2016, Munyegabe, Yiyi, & Hitimana, 2017,). Mathematics is one of the subjects known as accumulative subjects, and the probability topic starts from the early grades and accumulates through to Grade 12 and is among the underperformed topics.

It is against this backdrop that in this interventionist study, the researcher intends to work with Grade 6 teachers from rural primary schools to explore how using Kahoot! as a gamification technology and approach may facilitate the learning of Probability which is a Mathematics topic in Amathole East District.

1.1. The purpose and significance of the study

The purpose of this study is to find out how Kahoot! as a gamification technology in teaching, can support grade 6 teachers to facilitate the learning of Probability in Mathematics. Therefore, this study has the potential to accentuate professional development as it will produce evidence-based research on the use of gamification technology in the teaching of Probability in Mathematics. This interventionist study may transform the selected teachers through knowledge and skills to integrate gamification technology into the teaching and learning of Mathematics. Furthermore, the findings from the study might fill the knowledge gap on how technology such as Kahoot! can or cannot improve teaching in rural primary schools. This concurs with Yelland (2001), who suggests that the importance of ICT tools in rural schools should be on how best they can enhance Mathematics teaching and learning, given the enormous challenges that rural schools are faced with. This interventionist study will assist selected teachers in incorporating technological knowledge above their existing pedagogical and content knowledge. In addition, the results of this study will contribute as literature to future researchers. Lastly, through the results of this study, curriculum developers and education policy makers may benefit as they may be informed on how incorporating Kahoot gamification technology may assist in the facilitation of Probability across the grades and phases.

1.2. Research Goal

The main goal of the study is to explore how teachers make use of Kahoot! gamification to facilitate learning of Probability in their classrooms in the Eastern Cape rural primary schools. The following sub-research questions will be asked in an attempt to achieve this goal.

1.3. Research Questions

To achieve the goal of this study, the following research questions were posed:

1. What are the technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a Gamification technology in facilitating learning Probability mathematics in rural schools?

2. How do Grade 6 teachers make use of Kahoot! to mediate learning of Probability in mathematics subject in rural schools?
3. How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?

1.4. Clarification of terminology

It is appropriate to clarify the terms used in research for easy understanding and to explicate their relevance in the study. The terminology for this study has been defined as follows:

1.4.1. Kahoot!

Kahoot! is a game-based student response system (GSRS) that was invented in 2006 at the Norwegian University of Science and Technology (NTNU) through the Lecture Quiz research project (Singh et al., (2020). It is a pedagogical tool accessed online via the web or an Application (App), and it contributes to active learning. The teacher becomes the host of the game and creates quizzes. Alternatively, the teacher may use and may customise the pre-existing quizzes that are readily available on the platform. Learners access the game through a generated pin through their digital devices such as smartphones, tablets, laptops and computers (Serena et al., 2019, Ganapathy et al., 2020). The main aim of using Kahoot! in an educational setting is to enhance the teaching and learning processes.

1.4.2. Gamification

Gamification in this study refers to converting non-game-based educational content into games through the integration of appropriate technologies to arouse more interest in teaching and learning. Gamification is efficient for active learner involvement, and it accommodates different learning styles (Cauthen, 2020, Kapp, 2012, Nand et al., 2019, Deterding et al., 2020). It plays a key role in making the content to be attractive and is used to promote learner engagement which eventually leads to the attainment of learning outcomes.

1.4.3. Technology

The word technology is used interchangeably with Information and Communication Technology (ICT) in this study to refer to the digital tools that are used to support and transform teaching and learning. According to UNESCO (2010), ICT refers to the software application, internet, computers, laptops, handheld digital devices such as tablets, mobile phones as well as projectors that are used to access, communicate, transmit, process, store, retrieve and display information (UNESCO,2010). Teachers integrate technology to enhance quality teaching and learning so as to improve learner performance. In this study, teachers and learners had to access Kahoot! Technology and other supporting technologies to participate in teaching and learning.

1.4.4. Teacher

In the context of this study, a teacher is someone who plays a crucial role in assisting learners in acquiring knowledge in a school setting. It is someone with an accredited teaching qualification and registration which is in the practice of facilitating learning. The teacher's roles encompass educating, teaching, guiding, directing, training, assessing and evaluating learners in formal education. According to Azer (2005), one of the qualities of a good teacher is the ability to bring a wide range of skills and talents to teaching, whose teaching clearly presents and stimulates high-order thinking. A teacher is someone who inculcates a good learning culture in a school. For this study, the teacher has to play the role of organising ICT resources for learners, planning the delivery of content through the integration of ICT and creating a dynamic learning environment in which all learners feel free to participate in the learning process.

1.4.5. Teaching

In this study, the term teaching is used to refer to a process in which an enthusiastic and committed teacher commissions appropriate strategies to assist the learners in acquiring knowledge. This is supported by Crawford (2001), who suggests constructivism as one of the strategies that can be employed in the teaching process. He further explains that a constructive classroom is an environment in which teachers actively engage students in the learning

process. In a constructive classroom, learners fearlessly discuss amongst themselves and cooperate in groups constructing their own knowledge instead of listening to a teacher dispensing information. Therefore, it is the duty of the teacher in the process of teaching to carefully correct the misconceptions. In technology-based teaching, a teacher is more of a facilitator than a sage on the stage, whose duty is to facilitate active learner participation in the classroom.

1.4.6. Learning

Learning is a process in which skills, knowledge, attitudes, values, understanding and behaviours are acquired. An individual's past experiences are influential in learning as it acts as a foundation for one to build on what one knows, adding on what one does not know. I resonate with Jan De Houwer, Barnes-Holmes, and Moors, (2013), who define learning as the change of behaviour resulting from experience. This is due to the fact that I understand learning as the capability to do something one could not do before, but after social interactions, employment of mediation tools and internalisation of learning occurs, behaviour changes (Vygotsky,1978). In this study, learning occurs as a result of the interactions between the teacher and learners, among learners and through the use of technology as a mediation tool.

1.4.7. Probability mathematics topic

Probability is a numerical likelihood that something or an event will occur. It is the study of random events that have an implication of uncertainty of an outcome (Grinstein and Lipsey (2001). Probability in this study is a Grade 6 Mathematics topic introduced as a new concept with the inception of the Curriculum and Assessment Policy Statement (CAPS) (2011) in South Africa. The teaching of Probability in Mathematics is important as this is a topic that accumulates to higher Grades (Botanero, 2009). If learners could master it at a young age, there could be minimum difficulty in attaining better grades in higher classes. It has the potential to develop learners' ability to predict the uncertainties of the world.

1.5. Structure of the thesis

The outline of this thesis is structured into seven chapters.

Chapter 1: Introduction

This chapter introduces the research study. It provides a detailed background context in which the study was undertaken. The overview of the problem that the study intended to address is outlined in this chapter. In addition, this chapter covers the research aim and the research questions employed to achieve the goal of this study. Also, the essence of subsequent chapters is summarized.

Chapter 2: Literature Review

This chapter examines the relevant literature underpinning this study. Literature in this chapter has been reviewed based on the research questions reflected in chapter one of this study. The reviewed literature had been drawn electronically from platforms such as Google Scholar, ResearchGate, Science Direct, and reports from other institutions inter-alia. The literature reviewed focused on the use of Kahoot! in facilitating the learning of probability in mathematics primary school classrooms**.**

Chapter 3: Theoretical Framework

To enrich the study, this Chapter presents two theoretical frameworks that were employed for an in-depth understanding of how technology integration may influence the learning process. Socio-Cultural Theory (SCT) and Technological Pedagogical and Content Knowledge (TPACK) framework are the lenses through which this study is academically situated and contextualized. TAM and SAMMR models have been reviewed as the frameworks that could have been chosen to underpin this study, and the reasons why they were not the best choices are provided. Lastly, the limitations of the TPACK model have been discussed.

Chapter 4: Methodology

This chapter discusses the research design employed in this study. The rationale for the choice of qualitative interpretive approach is justified. The sampling criteria and size are discussed in this chapter. The research site, the data gathering techniques and instruments are outlined. The instruments used and the rationale, as well as the limitations of using such instruments, are discussed. For this study, semi-structured questionnaires, journal reflections, workshop discussions, non-participant observations, and semi-structured interviews as data generation tools were employed. In addition, this chapter dealt with the issues of positionality, data analysis, triangulation, and research validity and trustworthiness focusing on credibility, dependability, confirmability and transferability. Lastly, ethical issues are addressed in this chapter.

Chapter 5: Findings

This chapter presents the results of this study as generated through the triangulation of all the instruments employed**.** Semi-structured questionnaires, journal reflections, non-participant observations, and semi-structured interviews were instruments used to generate data for this study**.** The findings are presented thematically according to the research questions posed in Chapter one. The participants' responses are presented verbatim in order to allow the reader an opportunity to get the experiences and the interpretation of the context directly from the participants' point of view.

Chapter 6: Discussion of findings

This chapter presents the discussion of the findings. The findings from the data are compared and contrasted with the literature as reviewed in chapter two of this study. This chapter acknowledges the similarities between the findings as depicted from the gathered data and the findings of other studies as per the literature reviewed. The contradictions between the findings and the literature that were observed are also recognized in this chapter. This chapter delineates the findings as per the three research questions articulated in the first chapter. In this chapter, the application of the theoretical framework to the findings of this study is evident.

Chapter 7: Conclusions and Recommendations

This is the final chapter of the thesis. This chapter presents a summary of the main findings of the study. The limitations of this study have been discussed. This chapter presents a discussion of the conclusions and recommendations of the study. Furthermore, this chapter suggests possible areas for future research.

Chapter Two

Review of Related Literature

2.1. Introduction

This study seeks to explore how teachers make use of Kahoot! gamification to facilitate learning of Probability in their classrooms. The previous chapter provided the overview of the study and the presentation of the background to the study, the problem statement, the purpose and significance of the study and the research goals. This chapter examines the existing literature that is relevant to the study. According to Monash University (2021), literature is defined as a collection of published information in the form of books, journal articles of academic value and other sources on a particular area of research or topic. On the other hand, a literature review denotes an analytical synthesis and evaluation of research or non-research literature relevant to a particular topic or chosen area of study (Ramdhani, Ramdhani, & Amin, 2014). The main objective of this literature review is to build the researcher's knowledge for ease of understanding the existing research on the topic studied. Also, it enables the researcher to identify the gaps that exist in literature and be in a better position to fill those gaps, thus contributing to the development of knowledge in the field of study. This resonates with Hart (1998), who suggests that a literature review is done to understand previous research on the researcher's topic, checking what has already been done and how it was done and what the key issues are. Furthermore, I concur with Snyder (2019) as he articulates that a literature review provides the background to and justification for the research undertaken and also gives the opportunity to create a firm foundation for advancing knowledge. Literature in this piece of research has assisted the researcher in situating the study within the context of existing literature.

This chapter has espoused literature relevant to the use of Kahoot! gamification technology from electronic sources such as Google Scholar, Research Gate, Science Direct and Websites. Literature that aligns with this study has been reviewed and was discussed thematically in

relation to the following aspects: Probability topic in Mathematics teaching and learning, the role of technology in teaching Mathematics in South African rural schools, the incorporation of Gamification in basic education, use of Kahoot! as a Gamification technology in teaching and learning, and lastly, using Kahoot! gamification in mathematics teaching was explored.

2.2. Teaching and learning of Mathematics topic of 'Probability.'

Just to remind the reader, Probability has been explained in the previous chapter as the topic offered in the Grade 6 Mathematics syllabus in South Africa, which is the focus of this study. It was introduced in Grade 6 as a new concept when CAPS was presented in South Africa. Teachers' personal and pedagogical understanding of significant mathematical ideas has an enormous influence on their capacity to teach mathematics effectively and appropriately to learners' diverse abilities and interests (Borko, Eisenhart et al. 1992, Ball and Bass 2000). In this section, I will juxtapose and compare the studies that are pertinent to the definition of Probability, pedagogical requirements, the importance of teaching Probability and teachers' pedagogical experiences in teaching Probability.

2.2.1. Definition of Probability and pedagogical requirements

Probability is a numerical likelihood that something or an event will occur. This is in line with Grinstein and Lipsey (2001), who describe probability as the study of random events that have an implication of uncertainty of an outcome. Borovcnik & Kapadia (1991) allude to probability as a phenomenon "fixed by equal likelihood of all possible results" (p.77). Likewise, Siegmund (2020) also defines Probability as "a branch of mathematics concerned with the analysis of random phenomena" (p.1). The outcome of a random event is not predicted but determined by chance (Siegmund, 2020). All the above definitions indicate that an outcome cannot be predicted with certainty.

The CAPS document for Grade 6 requires the use of a dice, a coin and a spinner for learners to understand Probability (Tarr & Jones et al.,2007). For example, when tossing a coin, the probability is 1/2 as it is comprised of two sides, the head and a tail; therefore, all outcomes are equally likely to happen. This resonates with Siegmund (2020), who suggests "the statement that the probability of 'heads' in tossing a coin equals one-half, according to the

relative frequency interpretation, this implies that in a large number of tosses the relative frequency with which "heads" actually occur will be approximately one-half, although it contains no implication concerning the outcome of any given toss". Boverick & Bentz (1991) add that any answer could be expected then, and another form of causality is related to the inability to predict specific results. The coin can land on either head or tail. Both results are likewise unpredictable in the sense that there is no guessing procedure that guarantees 100% success; therefore, the answer (=) is chosen.

2.2.2. The importance of teaching Probability topic in Mathematics classroom

The teaching of Probability in Mathematics is important as this is a topic that accumulates to higher Grades, and if learners could master it at a young age, there could be minimum difficulty in attaining better grades in higher classes. This is supported by Botanero (2009), who posits that probability is pervasive in that it starts in primary school and continues through secondary and high school into university studies (p.1). Probability is useful for daily life and plays an instrumental role in other disciplines, it also responds to the need for basic stochastic knowledge in many professions, and probability reasoning is important in decision making (ibid). In the same vein, Batanero et al. (2016) postulate that Probabilistic reasoning is a mode of reasoning that refers to judgments and decision-making under uncertainty and is relevant to real life for all citizens, for example, when evaluating risks. In addition, Probability has the potential to develop learners' ability to predict the uncertainties of the world. For example, the learners proficient in Probability are able to interpret and predict weather conditions and graphical representations, and those who are likely to become Actuarians have expertise in Probability and can predict issues pertaining to real-life contexts (Gal, 2009). Furthermore, Tarr and Jones, (2007) opine that "consumers and citizens in today's information-rich society need to have an understanding of probability" (p.466). Also, Tarr and Jones (2007) advocate that "there is perhaps no other branch of the mathematical sciences that is as important for all students, college-bound or not, as probability and statistics" (p. 466). Therefore, the main reason for teaching probability is to provide students with understanding and develop their critical thinking to enable them to make interpretations and decisions accordingly in various real-life situations they are likely to meet (Tarr & Jones, 2007). I concur with Dvořáková et al.(2017), who elaborated that Probability constitutes a distinct

approach to thinking and reasoning about real-life phenomena. He further expatiates that Probability is entailed in thinking in scenarios that allow for the exploration and evaluation of different possible outcomes in situations of uncertainty and includes the ability to identify random events in nature, technology, and society, analysis of conditions of such events and derivation of appropriate modelling assumptions. I believe that the resources prescribed for teaching Probability in Grade 6 are limited, and it is against this backdrop that I opt to explore the incorporation of Kahoot as a gamification technology in the teaching and learning of Probability.

2.2.3. Rural Teachers' experience in the teaching of probability in the South African context

When Curriculum and Assessment Policy Statement (CAPS) (2011) was introduced for the first time in South Africa, Probability emerged as a new topic in Mathematics for Grade 6 that the teachers and learners had to engage on. This resonates with the statement by Butanero et al. (2004) that "nowadays probability and statistics are part of mathematics curricula for primary and secondary school classes in many countries" (p 1). In addition, Tarr & Jones (2007) allude that "over the past several decades, probability has emerged as an important topic for all students to learn, particularly those in the middle grades' (p.5). The majority of teachers are not competent in teaching this topic, and for some, Probability and Statistics were not even part of the modules during their pre-service training. This is commensurate with Butanero et al. (2004), who cites an example that "in Spain, prospective secondary teachers with a major in Mathematics do not receive specific training in statistics education" and that "the situation is even worse for primary teachers, most of whom have not had basic training in statistics and this problem is common to many countries" (P1). This is unearthed on the Department of Basic Education diagnostic report (Education, 2019) where as compared to others, the question on Probability was the least performed topic with 21% average performance in the National Senior Certificate (NSC) results. Furthermore, our district question-by-question analysis for 2017 to 2019 Grade 6 Mathematics reveals that Probability is not well performed even though it has lower mark allocation than other topics. Tarr and Jones (2007) highlight that "teachers may omit topics for a number of reasons, including a lack of preparation to teach topics from probability due to their own lack of experience or

misconceptions or a subsequent lack of confidence in their ability to teach such topics" (p.5). He further suggests the notion of insufficient time to teach all the topics, which may end up causing teachers to omit probability lessons, or else the available textbooks may not be sufficiently addressing learners' misconceptions (Tarr & Jones,2007). This confirms that, indeed, there is underperformance that surrounds the topic of Probability, and it could be attributed to many factors ranging from the teachers' incompetence to teach the topic, unavailability of enough time to teach the topic, or the lack of diverse strategies to teach the topic in a way that will be easily understandable to learners.

2.3. The role of technology in teaching Mathematics in South African rural schools

Globally, integration of technology across the curriculum is quintessential in the education system to mediate learning in the technology-driven era, the 21st century. The introduction of the White Paper on e-Education in 2004 in South Africa had good intentions for the country as it advocates for the transformation of the teaching and learning environment through changing pedagogic strategies to enable access to high-quality, relevant and diverse resources that foster communication and collaboration among learners as well as transition to digital learning and assessment (Education, 2004). In addition, Goal 16 and Goal 20 of the National Strategy for Learner Attainment (NSLA) allude to the improvement of professionalism, teaching skills, subject knowledge and computer literacy of teachers as well as learner access to a wide range of media, including computers, which enrich their education thus enhancing learning objectives and learner attainment (Education, 2015). According to Khambaria et al. (2010), many countries are in the process of exploring the capability of Information and Communication Technology (ICT) in improving and enhancing the learning of the e-generation, as well as it's potential in the achievement of efficiencies in the classroom instructions. Technology plays a significant role in Mathematics teaching and learning. According to Means and Haertel, (2004), a plethora of studies have found that ICT can support learning when appropriately integrated with teaching techniques, curriculum, and assessments. He further states that other researchers discovered that integrating technology into the classroom can improve mathematics teaching. For example, through constructivist pedagogy enhanced by technology integration, students explore and reach an understanding of

mathematical concepts. This approach promotes higher-order thinking and better problem-solving strategies (Ittigson and Zewe, 2003).

Teachers and students should opt to use technology tools in a manner that keeps mathematics and mathematics learning goals as the focus of instruction and not technology (mathematics, 2015). Mathematics technologies, when used strategically, support the learners in exploring mathematical concepts and identifying relationships.

A number of factors are attributed to the success of technology integration in Mathematics. For example, teachers' confidence and competence in technology determine the extent to which teachers integrate technology into their teaching and learning of Mathematics. This notion resonates with Leendertz et al. (2013), who propound a significant relationship between teachers' confidence and ICT applications. This is corroborated by Shin (2009), who postulates that Technological Pedagogical Content Knowledge (TPACK) is considerably important for teachers to integrate technology successfully into the teaching process. Umugiraneza et al. (2018) added that the technological pedagogical content knowledge (TPACK) of mathematics teachers contributes to more effective mathematics teaching in South African schools and that the further the improvement of TPACK of mathematics teachers, the higher their confidence increases in their ability to apply technology for teaching mathematics in South African schools. Professional Development Framework for digital learning (2018) defines TPACK as a framework that clarifies knowledge needed by a teacher for effective pedagogical practice in a technology-enhanced learning environment.

Technology has a profound influence on the way teachers teach, through stimulation of interest, designing efficient learning tools, collaborative learning and learner engagement. Teachers with TPACK are capable of accessing better subject content in the form of online resources like videos, simulations, digitized textbooks and education portals (education, 2018). Through TPACK, teachers are able to select technologies appropriate for specific content and pedagogical approaches in the instructional process. Concurring with this notion, Mistretta (2005), in his study on Integrating Technology into the Mathematics classroom, revealed that "when appropriately used, computers may serve to improve student mathematics achievement as well as to enhance the overall learning environment of the school" (p18). He

further postulated that teachers who received training in instructional technology were found more likely than those who had not to use computers in effective ways, such as in simulations, applications, and math learning games. In addition, technology was found to be effective in nurturing higher-order thinking skills in the mathematics classroom (Mistretta, 2005). Furthermore, Ngwenya (2015), in his thesis titled 'An experimental approach to the derivative using GeoGebra. School of Science, Mathematics, and Technology Education' explicates that when technology is to be integrated, the teachers need to adapt to strategies that support the use of technology and re-evaluate traditional teaching approaches, and I concur with him, especially when he suggests that technology integration is dependent on the teacher's mastery of the software packages and technologies available. This discussion reveals that the successful integration of technology relies on various other factors. For example, teachers' confidence, competency, attitudes, gender, age, access to ICT infrastructure and technical support may enable or constrain technology integration.

In contrast, the findings by Sanchez et al., (2012) suggest that technology initially complicates the teachers' practices instead of simplifying them. This attests that the use of technology in Mathematics is not smooth sailing as it is sometimes subjected to constraining factors. Sometimes the failure of teachers to integrate technology in their classrooms is due to problems that are beyond their control (Marwan, 2008; Mumtaz, 2000). Some challenges experienced by teachers when trying to implement ICT include the insufficient ability of ICT specialist teachers to teach students computer skills, lack of computer accessibility, lack of time and lack of financial support (Mumtaz, 2000). Similarly, Buabeng-Andoh (2012) identified poor ICT skills, low teacher confidence, insufficient pedagogical teacher training, absence of suitable educational software, limited access to ICT, the inflexible structure of traditional education systems and limiting curricula design as some of the reasons that inhibited the use of technology by teachers. In addition, the findings by Voogt et al., (2010) surfaced the reasons attributed by mathematics teachers for not integrating ICT in their instruction and "among others, lack of ICT knowledge in integration: lack of knowledge about ways to integrate ICT in the lesson and lack of training opportunities for ICT integration knowledge acquisition" (p.436).

On a similar note, some primary schools in South Africa; experience a lack of ICT infrastructure, which hampers the appropriate integration of technology into curriculum delivery. ICT infrastructure in education refers to the diverse ICT tools such as hardware, software, and networks that can be used to communicate, disseminate, create, assess, store, manage and retrieve information. For example, it includes computers, laptops, tablets, smart phones, visualizers, projectors, sound systems, interactive whiteboards, educational software, the Internet, digital books and many more. This definition is in line with Pelgrum (2001), who refers to ICT Infrastructure as the availability of equipment, software, Internet access and other similar resources in the school. The necessary hardware and software resources and access to the network play a role in fostering the teachers' ability to incorporate technology into mathematics teaching. Currently, in South Africa, there are disparities in terms of available ICT infrastructure in schools,some schools are well resourced than others. The schools are classified into Quintiles, where quintiles 1 to 3 are more poorly resourced than Quintiles 4 to 5. Most primary schools in quintiles1-3 do not have access to the Internet and other ICT resources; therefore, teachers teaching in the poorest schools integrate technology less than those from self-sufficient schools. This impacts the widening of the digital divide in the country (Butcher, 2003). The educators have few prospects to utilize instructional technology when the ICT infrastructure is not well provided for; therefore, it is unequivocal that lack of ICT infrastructure can be one of the factors that constrain the integration of technology in mathematics (Mosesa et al., 2012). The above literature suggests that the incorporation of technology in mathematics teaching motivates and excites learners such that retention and understanding of mathematics concepts improves.

2.4. The incorporation of Gamification in basic education

This section seeks to review related literature on the role gamification plays in basic education. The concept and gamification dynamics and features are explored.

2.4.1. The concept of Gamification

The concept of Gamification has become pervasive in the educational institutions of South Africa, especially in the 21st century, where a culture of innovation prevails. The literature

consulted demonstrates gamification for the educational context as a technique of converting non-game-based content into games through the incorporation of relevant technologies for the purpose of garnering more interest leading to activating learner involvement and accommodating different learning styles (Cauthen, 2020, Kapp, 2012; Nand et al., 2019). This notion is commensurate with Deterding et al. (2020), who postulate that "gamification is the use of game design elements in non-game contexts" (p.37). In addition, Decheva et al. (2015) explicate that "gamification is an approach that suggests using game thinking and game design elements to improve learners' engagement and motivation" (p.75). Likewise, Kapp (2012) suggests "gamification as "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" (p.37). Furthermore, Youssef (2020), in his paper alludes to gamification "as a simple yet still efficient approach… to make the content more attractive and engage users, especially in e-learning" (p.48). From the above definitions, it is clear that gamification should not include games that deviate from the content, and if handled with rigour, it leads to the achievement of certain learning outcomes.

2.4.2. Game dynamics and features relevant to basic education

Games are comprised of certain features such as freedom to fail, immediate feedback and progression inter-alia, which are relevant to the learning environment (Neustaedter, 2013, Nah et al., 2014, Dicheva et al., 2015).

Freedom to fail is an important dynamic that is useful in a classroom setting as it improves learner engagement (Neustaedter, 2013). The learners are not afraid to take risks, and failure is treated as a learning curve in a game, and learners become eager to repeat and do their best in order to move to the next level. As part of formative assessment, freedom to fail assists learners in focusing more on the process of learning rather than the badges or rewards. As learners explore content and engage in decision-making, they are also exposed to the consequences of poor decision-making during the game process (Neustaedter, 2013). In addition, Dicheva et al., (2015) postulate that " freedom to fail presumes no penalties on poor task performance and typically includes allowing students to revise and re-submit assignments" (p.80). Gamification allows learners to learn through their own experiences and

from their own mistakes. The positive relationship with failure is maintained through prompt feedback; that is why the freedom to fail dynamic is pertinent in the context of basic education (Neustaedter, 2013).

Feedback is another key game element that is effective in education. Kapp (2012) advocates that the prevalence of frequently targeted feedback is effective in teaching and learning and that teachers should harness this game dynamic through self-paced exercises, visual cues and frequent question and answer activities. This notion is supported by Nah et al., (2014), who opines that frequent, intensive, and immediate feedback is crucial for learning effectiveness and learner engagement. Likewise, Dicheva et al., (2015) agreed that shortened feedback cycles are more effective in education as they offer immediate rewards instead of long-term benefits which may be vague. Feedback is a useful vehicle for teachers to track the learners' progress.

Progression is another feature associated with gamification, which relates to the achievement of educational goals. According to Nah et al., (2014), progression is displayed in the form of levels, starting with easy and achievable tasks and progressing through the difficult ones requiring more effort and skills. This concurs with Dacha et al., (2015) as he posits that challenges are matched to the skills level of the player and become difficult as the player's skill expands,hence there is visible progression to mastery. Information in games is categorized in order to focus attention, and in this way, learning is scaffolded to guide and support learners (Kiryakova, 2017). Also, to engage the learners, it is better to always start with interesting content to grab their attention and to assess prior knowledge to tailor the lesson to address the specific learners 'needs (Neustaedter, 2013). The display of learners' progress in games scoreboards assists learners in engaging in a competitive spirit, taking chances and being overwhelmed with the desire to perform much better. This ends up unleashing their potential to achieve educational goals. Although gamification inspires the users to master content, it is not a one size fits all as some learners may feel frustrated in the process, therefore, teachers should blend their teaching to accommodate all types of learners (Lister, 2015). Freedom to fail, instant feedback and progression are the effective game elements mentioned in the reviewed literature, making learning fun, interactive and

entertaining. Learners become motivated to engage in a mathematics class, thus developing a sense of achievement. Therefore, gamification has an impact on the retention of knowledge.

2.5. The use of Kahoot as a Gamification technology in teaching and learning

According to Singh et al.. (2020) Kahoot! is a "game-based student response system (GSRS)that was initially devised in 2006 at the Norwegian University of Science and Technology (NTNU) through the Lecture Quiz research project" (p.79). The main aim was to create a platform to enhance a competitive knowledge interaction between teachers and students in a classroom setting by using the existing infrastructure (Singh et al. 2020). Literature provides complimentary definitions and views about Kahoot. According to Serena et al. (2019) 'Kahoot!' is a free online "game-based pedagogical tool that can be accessed on a web browser or an app, with the potential to turn a classroom into a gameshow and is associated with active learning, which impacts on improved academic achievement" (p.79). Also, Ganapathy et al., (2020) add that the teacher becomes the host of the game show and creates or uses premade quizzes, discussions or surveys and allows the learners to access the game through a generated pin. Learners use their digital devices like smartphones, iPads, tablets, laptops or desktops to log in as individuals or as teams to provide fast answers. The games are displayed on a shared screen, and learners start to compete against one another to be on the scoreboard.

Kahoot! gives instant feedback on how much the learner knows about the topic (Ganapathy, 2020). Teachers are able to monitor the progress of their students while they participate in a "game" through a distribution chart that reveals how all participants are performing in each game. This allows them to rectify grey areas immediately. Kahoot could be a game-changer in education as it transforms the traditional classroom into a game field where everyone is not afraid to fail,instead, everyone is prepared to work his or her way to the top (Ganapathy, 2020). Having defined Kahoot! it is now relevant to sketch through the use of Kahoot as a Gamification technology in teaching and learning.

One of the merits of using Kahoot as a learning tool is that it promotes learner engagement during instruction. This is in line with Cauthen et al., (2020), who articulate that Kahoot

makes learning fun and interactive, and it involves the practical application of skills as it unleashes the learners' potential to portray their problem-solving and critical thinking skills. When learners are actively engaged in learning, the chances are that their performance may improve.

Another merit of using Kahoot! in learning is that it encourages peer collaboration which is beneficial in teaching and learning. According to Prieto et al. (2019) Kahoot! fosters a positive relationship between students and teachers. Also, Licorish et al., (2018) echo that through the provision of a fun platform on which to engage, "Kahoot! gives students more opportunities to interact and engage with the lecturers, peers and lecture content" (p.12). Furthermore, Yukawa (2019) emphasises that "Kahoot is designed to provide learners with collaboration in studying to promote learning motivation" (p. 288). This collaboration emanates from working with others to reach specific goals. The classroom environment changes into an interesting learning space full of fun and competition through the utilization of Kahoot! and this has a positive impact on learner improvement. On the other hand, the collaboration of learners in the classroom comes at a cost,the classroom may become chaotic as it is noisy. The activities may be time-consuming compared to when individuals do them and the extroverts may dominate the activities. Kahoot! as a gamification technology, is not immune to limitations. One limitation of Kahoot is that it creates competition among learners. In their findings, Licorish et al. (2018) mention that "negative aspects of competition came into play when students focused more on the competition and having fun rather than learning" (p.13). For instance, "in their desire to compete, some students rushed to answer questions, not taking the time to understand the questions or the answers" (ibid.p.13). This means that in every learning environment, it should always be considered that the inclusion of Kahoot! is part of enhancing mastery of content. Another shortcoming of Kahoot! is that it is sometimes subjected to infrastructural challenges such as malfunctioning or lack of devices, lack of internet access and connectivity challenges which may hinder the learning process. I concur with Pektaş & Kepceoğlu (2019) when they articulate that "as all gamification applications are based on some technology, possible technological problems may affect courses and instruction" (p.70). For this reason, I suggest that Kahoot! should be used in conjunction with other technologies or instructional methods. In summary, today's learners are digitally fluent. The demand for

teachers who are compatible with them in terms of incorporation of various technologies in teaching and learning, including the gamification technologies, is high, which may enhance the improvement of learner collaboration and engagement.

2.6. Using Kahoot! gamification in mathematics teaching

Kahoot! is one of the pivotal platforms through which gamification technology can be integrated into mathematics teaching and learning (Rahman, 2019). This is because one of the key aspects in Mathematics teaching is learner engagement. Most of the studies were conducted on the integration of Kahoot! gamification accentuates that this technology makes teaching and learning more interactive. For example, Prieto et al., (2019) postulate that the use of kahoot! gamification improves participation and motivation while increasing meaningful learning in students by fostering the desire of students to learn. In the same vein, Prieto et al. (2019), opine that young people learn best when something is relevant and interesting to them and when there is a social connection with the concept they learn. Likewise, Sabandar et al., (2018), in the study "Kahoot Brings Fun into the Classroom", discovered that Kahoot! in the classroom was more useful, fun and engaging. The learners get the opportunity to learn the intended materials during the game and use Kahoot! proved to be effective in motivating and engaging learners in the classroom. They further explicated that Kahoot presents a fun and challenging way to engage modern learners in learning and easily fits to a wide range of learning environments. According to El-Nasr and Smith, (2006), the utilisation of gamification technology in education supports engagement in a range of academic settings, including Mathematics and enriches the student learning experience. Several studies on Kahoot! gamification (Sartika & Octafianti 2019, Polydoros & Balaris, 2019, Licorish et al., 2017, Göksün & Gursoy, 2019, Sabandar et al., 2018, Rahman & Rahmadani, 2019) elucidate that Kahoot! is a gamification technology that enhances student engagement, motivation, problem-solving and critical thinking skills, improved students' interactions with their peers and teachers and improved classroom dynamics. Kahoot! gamification enables direct acquisition of knowledge and skills through learner involvement and participation of motivated learners, thus engaging and encouraging interaction to enrich the student learning experience required in the mathematics classroom. The above discussion resonates well with Vygotsky's (1978) Socio-cultural theory as it advocates for learning through social interaction

and the use of mediation tools. The studies consulted mentioned interaction between teachers and learners. They also mentioned Kahoot! as a mediation tool with which the teachers and peers interact as social mediation tools in the process.

Kahoot! gamification technology ensures knowledge acquisition, retention, retrieval and prompt feedback; hence it works best for the retrieval practice required in mathematics classrooms. Kahoot! is useful in assessing learning acquisition simply and accurately as the teacher downloads the final results, reports and then identifies the students' learning acquisition based on the result, thus enhancing the quality of teaching and learning and leading to improved learning outcomes (Rahman & Rahmadan, 2019).

This coincides with Prieto et al., (2019) who reverberates that Kahoot! comprises a battery of questions that can be launched at the beginning of the lesson to check learners' prior knowledge or at the middle or end of the lesson to check knowledge acquisition. Through Kahoot!'s feature of immediate feedback on the learner's performance, the teacher is informed of the amount of learning achieved by learners and is able to detect problems and misconceptions and may immediately devise means to rectify them. The findings of the study "Students' perception of Kahoot!'s influence on teaching and learning" by Licorish et al., (2017) attest that Kahoot! enhances students' problem-solving and critical thinking skills, triggers sustainable attention and focus in the classroom and motivates students to pay attention, capturing their focus and interest during the course as they also need to be attentive to perform well in Kahoot! This is consistent with Wang (2015), whose findings allude to the positive effects of enhanced attention and healthy competition of Kahoot, which are the skills that play a key role in Mathematics teaching and learning.

Kahoot! gamification technology has its own drawbacks. Rahman & Rahmadan (2019) found that one of the challenges of using Kahoot! in the classroom is that some distractions are detected as students become too excited and start talking to one another while trying to join the game. In addition, Prieto et al., (2019) concur and argue that the teachers and students may be overwhelmed by the large amounts of information and that the lack of teachers' ´and students´ training would reduce the potential of ICT in enhancing teaching and learning because of the way it is integrated into the classroom. Also, ChanLin, Hong, Horng, Chang,

& Chu, (2006) concurred that some educators face challenges in shifting from traditional lesson formats towards methods that can help learners to understand the materials better using technology. This is, therefore tantamount to the TPACK theory by Mishra and Koehler (2009) underpinning this study as it advocates that the pedagogical and content knowledge directly influence the incorporation and implementation of technology in the classroom.

Furthermore, Sabandar et al., (2018) accentuated that lack or poor internet access is the downside of using Kahoot! in the classroom. As Kahoot! requires Internet, in areas where there is no internet, this gamification technology can not be used and when the internet connection is poor Kahoot! can not be effectively implemented, and learners may experience difficulties in joining the game. Sometimes the Kahoot! games may be meaningless and not relevant to some Mathematics topics rendering the gamification technology not the best solution for some of the topics.

2.7. Conclusion

This chapter discussed 'Probability' topic in Mathematics teaching and learning with the main focus on the definition and pedagogical requirements of Probability as well as the importance of teaching probability. This was followed by a discussion on the rural teachers' pedagogical experiences of teaching probability in the South African context. In addition, this chapter discussed the role of technology in mathematics teaching in South African rural schools. The incorporation of gamification technology in basic education was reviewed, followed by the use of Kahoot! as a gamification technology in teaching and learning and lastly, the use of Kahoot gamification technology in Mathematics teaching was discussed in this chapter.

The reviewed literature unearthed the existence of a gap in Gamification technology and the teaching of probability. No literature was found on the use of Kahoot! in the teaching of probability, especially in the rural schools of Amathole East District. Literature for gamification in teaching and learning was studied, and that of Kahoot! gamification and mathematics were limited. A gap was therefore identified and a need for research on Kahoot! gamification technology and probability were established.

The next Chapter focuses on the theoretical framework underpinning this study.

Chapter Three

Theoretical Framework

3.1. Introduction

The previous chapter review literature and reports related to the focus of the study presented in this thesis. This chapter focuses on the theoretical framework that guides this study. A theoretical framework is a bedrock upon which a study is constructed. It is intended to define patterns and give meaning to observations made by researchers (Adom, Agyem, & Hussein, 2018). It is a lens through which a study is academically situated and contextualized to support and enrich one's thinking (Lester, 2005). In addition, Camp (2001) corroborates that a theoretical framework is pivotal in understanding how and why phenomena occur, giving direction to the research and assisting with the interpretation of the study. Likewise, Welman, Kruger, and Mitchell (2011) opine that a theoretical framework encapsulates "a statement or a collection of statements that specify the relationships between variables to explain phenomena" (p.21).

A theoretical framework should resonate with every aspect of the research process and its selection depends on the discipline of the research in question (Adom, Agyem, & Hussein, 2018). It plays a fundamental role in connecting the researcher to existing literature (Herek, 1995; Smyth, 2004) and providing assumptions that guide the research (Miller, 2007). It assists in choosing the appropriate questions for the study (Miller, 2007) and guides the choice of research design (LeCompte & Preissle, 1993). It provides a lens that guides the researcher toward appropriate data gathering and data analysis methods (Miller, 2007, Adom, Agyem, & Hussein, 2018).

Analytical Framework is instrumental in facilitating the sense-making and understanding of particular phenomena in the research process; hence it is crucial in guiding data gathering, collation, storage, analysis and interpretation in a way that produces concrete outcomes (Coral & Bokelmann, 2017). This study will be broadly grounded through the amalgamation of

Vygotsky's (1978) socio-cultural theory (SCT) as a theoretical framework and Technological Pedagogical and Content Knowledge (TPACK) theory as an analytical framework.

According to the Socio-cultural theory, society and the interaction within the society are paramount in learning and development (Mitchell, Myles, & Marsden, 2013). The significance of the socio-cultural theory in this study is to understand how the interaction of teachers and learners mediated by technology may or may not lead to the successful learning of Mathematics in rural primary schools. On the other hand, TPACK emerges from the notion that teachers need to align technological knowledge to their content and pedagogical knowledge for effective integration of technology into teaching and learning (Koh, Chai, & Tsait, 2010, Voogt, Fisser, Roblin, Tondeur, & van Braak, 2012). This concurs with Koehler and Mishra (2005), who advocated for the TPACK framework to address the knowledge necessary for teachers to integrate technology in their classrooms. In this study, TPACK will assist in exploring how Grade 6 teachers' integration of gamification technology into their pedagogical and content knowledge may be effective in the teaching and learning of Probability in Mathematics. The use of these two theories is appropriate as they are not parallel but complementary to each other. In this Chapter, Vygotsky's socio-cultural theory and Technological Pedagogical and Content Knowledge are discussed in depth.

3.2. Socio-Cultural Theory

Lev Vygotsky (1896-1934), a Russian Psychologist, is the main custodian of the Socio-Cultural Theory (SCT), which emerged as an important element of the learning theory (Marginson & Dang, 2016 & Abu Bakar & Som, 2018). SCT received growing attention, especially in education research, from the 1960s, long after Vygotsky departed from the earth (Marginson & Dang, 2016). Vygotsky's (1978). SCT explicates that social, cultural and historical contexts are fundamental in the process of knowledge construction. This harmonizes with Wang, Bruce, and Hughes (2011), who opined that knowledge is constructed through interaction in social, cultural and historical contexts and is shared by individuals. According to SCT, human intelligence develops as a result of individuals participating with others in a social environment towards the achievement of community goals (Abu Bakar & Som, 2018). For instance, the acquisition of language emanates through social interaction. Children acquire

language from the interactive guidance of their parents, adults and other children who are more proficient than them in their surrounding environment. This is congruent with Vygotsky (1978), who orates that social interaction is linked to human development. He elaborates that mental processes begin with relationships from the inter-psychological level and move on to the intra- psychological level and that the thinking processes depend on the social setup of a particularly given culture. This reveals that mental functions are first experienced in the interpersonal plane, being performed together with others. Through the internalization process, the individual appropriates them into the intrapersonal plane (Brown, 2016). For example, if we talk of character or personality formation, it is from the external to the internal process and as averred by Marginson & Dang (2016) that the child development starts from the social level (external) to the individual (internal). Also, thinking development does not start from individual to social but from social to individual. Furthermore, Dang (2016) attests that socio-cultural theory emphasizes the dominant role of social experience in human development. This is also supported by Wertsch (1991), who suggests an interdependence between individual and social processes in learning and development. Therefore, this explanation affirms that collaboration with others is key to learning.

This study seeks to explore how learning is facilitated through the integration of gamification technology in classroom practice. Therefore, SCT is the appropriate theory as it leads to interpersonal meaning-making during learning through play and interaction of children with one another (Abu Bakar & Som, 2018). In this study's context, the following concepts: Social Interactions, mediation of learning, and the zone of proximal development as drawn from Vygotsky's socio-cultural theory, are the three fundamental principles that will be implored.

3.2.1. Social Interactions

Social interactions are imperative in the enhancement of effective teaching and learning process. According to Vygotsky (1978), social interactions are a foundation of learning and development. Knowledge construction originates from social interactions and encapsulates exchanging of ideas between more knowledgeable others (MKOs) and less knowledgeable others (Shabani, 2016). Through interactions with more experienced others, knowledge and skills are transformed from the social realm into the cognitive pane through the process called

internalisation (Shabani, 2016; Lantolf, 2008). According to Wang, Bruce, and Hughes (2011), internalization is a meaning-making process in which the interpersonal process is transformed into an intrapersonal development as a result of collaborative engagements in activities between two or more people.

In the context of this study, learning took place among Grade 6 Mathematics teachers as I, the researcher, interacted with them in an effort to capacitate them on the use of Kahoot! in teaching. The researcher was the MKO and mediated the training until the teachers mastered the utilization of Kahoot! Interactions among the teachers as peers assisted them in mastering the content of the training, and they were able to develop their own Kahoots. Having mastered how to use Kahoot! in teaching, the teachers interacted with learners as they were using Kahoot! in the process of learning Probability. Teachers were recognised as the more experienced others (MKOs) and guided the learners towards achieving the desired goals. On the other-hand learner to learner, collaboration was fostered as Goos (2004) advocates that learners learn best when working in joint collaborations with others. Learners were able to collaborate even though they had to maintain the appropriate social distancing in observation of the COVID-19 protocol. They interacted effectively from their distance.

3.2.2. Mediation

Mediation is one of the key aspects of Vygotsky's (1978) socio-cultural theory of learning. As we humans interact with the outside world, our minds are mediated through the use of tools (Lantolf, 2001) and in collaboration with others, tools become useful in controlling the world according to our needs and goals (Nieto, 2007). This resonates well with Balbay & Dogan, (2016), who articulates that the "human learning process is a mediated process" (p.66). Learning is mediated through the utilisation of tools that are provided by the environment, which are material tools, and in the context of this study, these are represented by mediation through the use of Kahoot! as a gamification technology. Secondly, the behaviour of other human beings in social interactions and peers and teachers acted as social mediators in the study. Lastly, a system of symbols, with language playing a significant role. All of these mediate our actions as we work through them to achieve our practical goals (Vygotsky, 1978; Nieto, 2007 Lantolf, 2008, Balbay & Dogan, 2016). For this study, two

tools were employed, the experts (social mediation tools) who mediated learning and the artefacts (material tools), which was Kahoot! gamification technology (Vygotsky 1978). Kahoot! as a material mediational tool, provided the much-needed context in which mediation of learning of Probability in Mathematics occurred. The researcher, teachers and peers, as significant people, played a social mediation role in-order to enhance learners learning experience.

3.2.3. The zone of proximal development (ZPD)

The concept of the zone of proximal development (ZPD) has become ubiquitous in the field of education. According to Ghaemi (2011), Vygotsky's theory is nested on the idea that "the potential for cognitive development depends upon the zone of proximal development (ZPD)… attained when children engage in social behaviour" (p.1550). Vygotsky (1978) elucidates that "ZPD is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with capable peers" (p86). To simplify this, Brown (2016) elaborates that ZPD has two boundaries: the lower boundary entailing what the child can do unassisted with reasonable competence and the upper boundary encompasses what the child can meaningfully contribute to doing, with help (mediation) from the other (MKO/ peer). This concurs with Wang, Bruce, and Hughes, (2011), who alludes that there are two levels of development, the actual level of development and the potential level of development. The actual level of development entails what a person can do independently without any assistance from MKOs. This is the level that Levykh, (2008), Lantolf, (2008), Balbay and Dogan, (2016) refer to as the current level of natural, unmediated development, which is revealed by the Child's or person's capability of problem-solving when working alone without any help. In contrast, the level of potential development is what a person can achieve when supported through interaction, cooperation and collaboration with more advanced peers, adults or instructors (see figure 1).

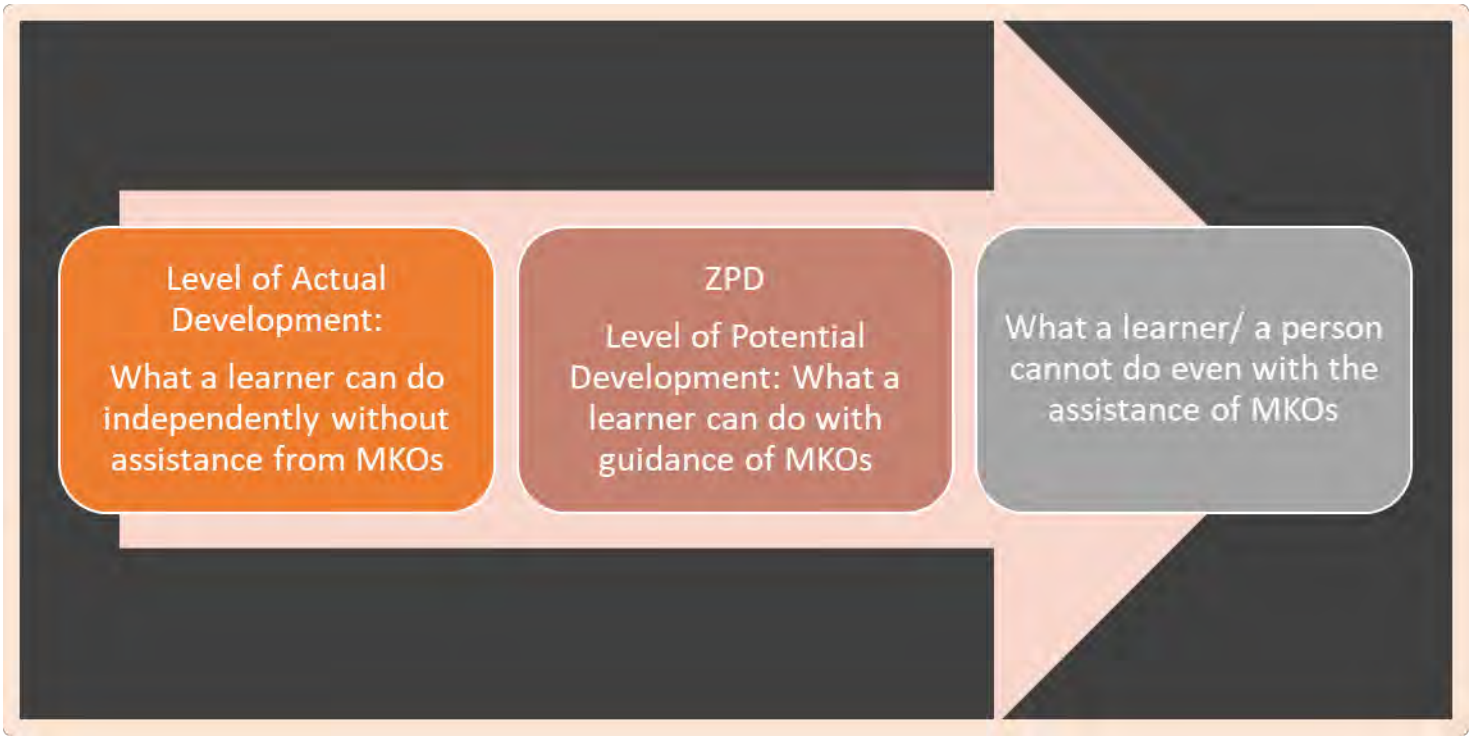


Figure 3. 1: ZPD Adapted from (Lui, 2012)

Vygotsky's SCT was basically designed for learners, but I resonate with Shabani (2016), who applied the SCT for teachers' professional development. The SCT theory also applies in the context of this study since teachers were trained on the utilization of Kahoot as a gamification technology in teaching by the teacher educator who is the researcher in this study. The teachers came with their pre-existing knowledge of ICT integration and use of gamification technology (their level of actual development) and were assisted by a more significant other- the researcher to learn to use gamification technology in teaching probability (Level of potential development-ZPD). The teachers were moved from their comfort zone, where there is little development increase, to a zone that is beyond them while being guided. There was a possibility also that the knowledge could be beyond the reach of some teachers even with the help of capable others. In this case, the teachers were grouped according to their level of expertise so that appropriate instruction could be used for each group. After they had all mastered the skill, they used the technology to assist learners in learning of Probability topic.

Therefore, the developmental difference between what the learner already knows and can do independently; and what is to be learned or what learners can do with the help of more knowledgeable others is what Vygotsky (1978) terms the Zone of Proximal Development (ZPD). This is tantamount to Levykh's (2008) reflection that Vygotsky's ZPD is a cultural process of assistance through cooperation and collaboration, which uses tools, signs and symbols to mediate the process of learning. The ZPD enabled this study to establish whether the tool (Kahoot) is able to facilitate the highest level of learner attainment in Grade 6 Probability or not. I now divert my attention to TPACK.

3.3. Technological Pedagogical Content Knowledge- TPACK

This study is underpinned by Technological Pedagogical Content Knowledge (TPACK) theory as the analytical lens in an effort to address the research questions. According to Erdogan and Sahin (2010), TPACK is a framework originally developed through adding technology knowledge to a construct of pedagogical content knowledge (PCK), which was pioneered by Shulman (1986) in order to address the knowledge needed by teachers to effectively integrate technology in the teaching and learning process (Spiro & Jehng, 1990). TPCK was then changed by Mishra and Koehler (2009) to TPACK for easy pronunciation (Koh, Chai, & Tsait, 2010).

For most teachers in Amathole East District, technology was never part of their pre-service training and therefore, they find it challenging to integrate technology in their classrooms. TPACK is therefore, a pivotal framework for understanding the teachers' knowledge and ability to integrate technology in their classrooms. This notion resonates with Mishra and Koehler, (2006), who articulate that knowing how to use technology is not the same as knowing how to teach with technology, and therefore, teachers' workshops on the software and hardware do not necessarily imply that teachers will become intelligent users of technology for pedagogy.

The aim is to find out how the teachers' understanding of educational technologies and PCK interact with one another to produce effective integration of technology into teaching (Koehler & Mishra, 2009).

TPACK theory is relevant for this study as the focus is to empower teachers with technological knowledge to use gamification in teaching to maximize the learning of probability in the sixth Grade Mathematics. This concurs with Shin (2009), who articulates that "what the Technological Pedagogical Content Knowledge (TPACK) means to teachers is considerably important to integrate technology successfully into the teaching process".

TPACK framework comprises seven knowledge constructs termed: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and Technological Pedagogical and content knowledge (TPACK) that the teachers must possess for effective integration in the teaching and learning environment **(See Figure 3.2.),** (Dewi, 2016: Koehler & Mishra, 2009, Koh, Chai, & Tsait, 2010, Voogt, Fisser, Roblin, Tondeur, & van Braak, 2012, Spiro & Jehng, 1990). For this study, attention is paid to two TPACK constructs: Technological Knowledge TK and Technological Pedagogical knowledge (TPK), even though other constructs are also useful.

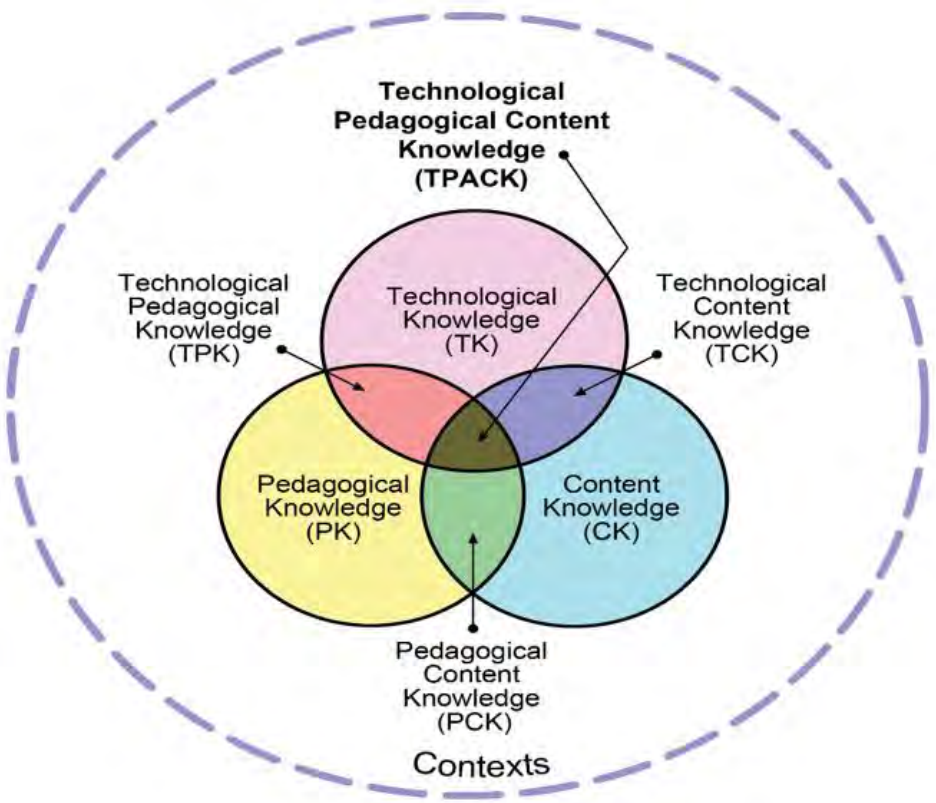


Figure 3. 2: TPACK Framework and its knowledge components

Source: https://images.app.goo.gl

3.3.1. Content Knowledge (CK)

Content knowledge is basically the knowledge of the subject matter to be taught (Mishra and Koehler, 2009) to learners, and it is the main point of departure as teachers need to have extensive knowledge of the ideas, facts, conceptions and theories of the discipline in which they teach. This is in line with Erdogan and Sahin (2010), who postulate that CK "is the field-specific knowledge"(p.2708). The knowledgeability of Probability as a Mathematics topic is key for this study before we can integrate technology, the teacher should have a content knowledge of the topic as the aim of ICT integration is to enhance learner performance in a

particular content. The participants selected for the study are Mathematics teachers who are already in practice and the assumption is that they know what to teach, which is the subject matter, and in the context of the study, this refers to knowledge of Probability.

3.3.2. Pedagogical Knowledge (PK)

Pedagogical Knowledge involves how a teacher teaches. Mishra and Koehler (2009) posit that PK is teachers' deep knowledge about the processes, practices or methods of teaching and learning. Also, Kartal & Afacan (2016) explain PK as the teachers' knowledge of general pedagogical activities, it incorporates teaching and learning processes, goals and strategies, lesson plans, classroom management, and formative and summative assessment inter-alia. According to Koehler at al., (2013) PK also applies to the understanding of how learners construct knowledge and acquire skills, general classroom management and student assessment. In essence, it is the method of teaching in order to meet learners' needs. Pedagogical knowledge is key to this study. For example, as the teachers will be using gamification technology to teach mathematics, they need to be well versed in the constructivist strategies of teaching and learning.

3.3.3. Technological Knowledge (TK)

Since this study is premised on the use of Kahoot! as a gamification technology in teaching, it is necessary to have knowledge of various technologies useful in teaching and learning situations (Schmidt al., 2014). In addition, Wang (2009) refers to TK as the teachers' competencies in utilising the ICT Tools. For example, when using Kahoot! the teacher must be familiar with connecting the projector to a laptop or any computer and surfing the internet using search browsers, tablets or computers. Technological knowledge is imperative even though Kahoot does not necessarily need high computational skills to conduct.

3.3.4. Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge (PCK) implies that the teachers possess the subject knowledge and are also in possession of the knowledge on how to teach specific content and should therefore be capable of considering the relationship between pedagogy and content. Furthermore, Kartal (2016) opines that "the main focus should be how disciplines differ from each other and whether different disciplines can be taught with the same instructional strategies"(p.4).This concurs with Kartal (2016), who posits that PCK is the teachers' ability to transfer knowledge to learners in an understandable way. This is a unique feature for teachers as they explore the strategies relevant to impart certain content for easy understanding by learners. This resonates with Harris et al. (2007) as they stipulate that PCK refers to teaching knowledge applicable to a certain subject area. After training the teachers on Kahoot, they will be able to develop classroom activities using Kahoot to teach Probability. Teachers know Probability (subject matter) and will then use technology as part of the strategy to present the content interestingly and understandably.

3.3.5. Technological Content Knowledge (TCK)

Technology and content are interdependent. Certain technologies are suitable for certain content; therefore, technology is not a one size fits all. According to Koehler and Mishra, (2009), a choice of technologies affords and constrains the type of content that can be taught.The choice of technology directly impacts the presentation of the content, and with a good choice, a teacher may be able to accommodate all the learning styles of learners inside the classroom. For this study, teachers were exposed to Kahoot! gamification technology and later expected to easily integrate it into their teaching. For instance, Kahoot! cannot be suitable for all the content presented, teachers were able to create Kahoots appropriate to their content.

3.3.6. Technological Pedagogical Knowledge (TPK)

The aim of this study is for teachers to change strategies of teaching mathematics by incorporating gamification technology with the intention of enhancing learner improvement. This concurs with Koehler et al. (2013), who contend that TPK is an "understanding of how teaching and learning can change when particular technologies are used in particular ways". In the same vein, Margenum-Leys & Mars (2002), quoted in Erdogan & Sahin (2010), states that TPK requires an understanding of general pedagogical strategies applied to the use of technology. The teachers will automatically change the teaching strategies when using Kahoot!. A learner-centred constructivist approach is likely to be dominant in Kahoot! Classrooms.

3.3.7. Justification for using TPACK over other frameworks

There were other analytical frameworks that were considered before selecting TPACK as a model that is suitable for this study. Among a number of models that assist in explaining the integration of technology in the classroom, Technology Acceptance Model (TAM) by Davies, (2009) and the SAMMR by Puentedura, (2006) were reviewed and compared closely to TPACK.

3.3.7.1. The TAM Model

The technology acceptance model (TAM) is a framework that was initiated by Davies; (1989) and is widely applied in most studies. This model is premised on two constructs, one being perceived ease of usefulness (PEOU) and the other, perceived usefulness (PU), as being predictive of the acceptance of technology by end-users (Qingxiong & Liu, 2004). The focus of this framework is that the PEOU and the PU have a direct influence on the adoption, acceptance and utilization of technology by users.

According to Davis (1989), perceived usefulness is the extent to which a person believes that using a specific application system will enhance his or her job or life performance, while perceived ease of usefulness (PEOU) can be defined as the extent to which the user expects

the targeted technology to be free of effort. This notion resonates well with the attitude of the user as to whether the technology will be accepted or rejected.

There is a potential for incorporating a variety of new technologies in an educational environment to enhance the transfer and acquisition of knowledge; therefore, technology acceptance by users is pervasive hence TAM is an attractive model worldwide. This implies that the success or failure of technology lies in the acceptance by the users. Moreover, according to Mreeza (2017), there is a wide range of factors that influence the decision of an individual to accept technology. For example, age, gender, culture, environmental factors, experience and self-efficacy are some of the attributes that are influential in technology acceptance and utilisation (Lee, Kozar, & Larsen, 2003 & Shachak, Kuziemsky, & Carolyn, 2019;) In addition Mreeza, (2017) narrates that the main purpose of TAM is to determine the extent to which external stimuli affect the internal factors such as beliefs and attitudes. For example, a decision by an individual teacher to use technology is determined by the extent to which he or she believes whether that particular technology has the potential to enhance teaching and learning or not. In simple terms, the characteristics of a potential technology influence the way teachers may perceive it as easy to use or not.

TAM has been subjected to criticism by various researchers and scholars. For instance, Lee, Kozar and Larsen, (2003) argue that it is not easy to put TAM into practice as it denotes that inorder for technology to be adopted, it must be useful and easy to use but does not specify what exactly makes technology to be useful and easy to use. The above authors further suggest the incorporation of age, gender, experience, self-efficacy and the environment as factors that enhance technology acceptance among end-users. I also concur with Ajibade (2018, pp. 4 & 9), who elucidates that TAM "is useful for the personal use of Technology" and is not "envisioned to address technology use in other contexts". TAM seems to be useful in explaining the adoption of technology rather than the applicability of the technology in an educational context. This is in line with (Shachak, Kuziemsky, & Carolyn, 2019) as they posit that TAM is characterized by over simplicity as the main focus is on perceived ease of usefulness (PEOU) and perceived usefulness (PU) instead of studying the actual use of technology. Issues like advocacy, capacity building, compatibility of technology with the intended usage, the support given to users, prior experience in technology utilization,

teamwork, time constraints and other contextual factors are not seriously taken into account on the application of TAM even though they are instrumental in determining why is technology accepted or rejected. As a researcher in this study was looking for a model that is suitable in an educational context where technology is used for the purpose of integration into the educational content and the strategies of teaching and learning, TAM was found not to be the best choice of theoretical framework hence it was eliminated.

3.3.7.2. The SAMR Model

SAMR is another model that was taken into consideration when the theoretical framework for this study was at the planning stage. It is a framework that was developed by Puentedura (2006) for selecting, using, and evaluating technology in education (Romrell, Danae Romrell, & Kidder, 2018). SAMR is an acronym derived from four different classification levels; substitution, augmentation and redefinition (Hamilton, Rosenberg, & Akcaoglu, 2016). It is a framework that is used to describe, categorise, and assess how teachers incorporate technology in classrooms (ibid). Its intention in the education system is to encourage teachers to enhance quality teaching and learning through the use of technology. Hamilton, Rosenberg and Akcaoglu, (2016) and Gorman (2020) explicate the four levels of SAMR Model as follows: Substitution is when technology is used as a replacement for traditional tools without any functional change. For example, when a PowerPoint presentation is done to, substitute the chalkboard. Augmentation means that technology is used as a substitute tool to improve learners' experience. For instance, a presentation on a water cycle topic can be enhanced with the use of a video clip to increase learner productivity. Modification means that technology gives room for task alteration. To illustrate, a learner may create their own graphics in order to redesign the existing material. At this level, the lesson design and the learning outcome change. Redefinition is when technology allows for the creation of new tasks that were previously not possible without technology. For example, when learners or teachers in South Africa collaborate with other learners or teachers in other countries to discuss a certain topic, for instance, the impact of global warming in different countries.

According to the critical review by Hamilton, Rosenberg, & Akcaoglu (2016) the main criticism of the SAMR model is that SAMR does not take context into consideration. For

example, “infrastructure or resources, students’ individual and collective needs, teacher knowledge and support for using technology are not recognized” (Hamilton, Rosenberg, & Akcaoglu, 2016 p. 7). Different educational contexts impact educational outcomes, and any model designed for teaching and learning should take cognizance of the environment in which teachers teach and learners learn. In addition, Hamilton, Rosenberg, & Akcaoglu (2016) opine that “because SAMR does not acknowledge aspects of context, attempts to connect the SAMR model to research and teaching practice may be a challenge” (p8).

The main intention of the SAMR model is to categorise and align teachers with their levels of technology use and how they move up the SAMR ladder. The focus of technology integration into teaching and learning becomes minimal as the main objective is about changing the level of technology use rather than the learning processes (Hamilton, Rosenberg, & Akcaoglu, 2016). Based on the above discussion SAMR was also not the appropriate choice for the current study and was also turned down.

3.4. Limitations of the TPACK Model

Although TPACK model is vital for the successful integration of technology within the classroom, it contests limitations and barriers. For example, factors such as institutional level barriers, teacher level barriers, and technology-related barriers (Bingimlas, 2009; Ling, Chai, & Tay, 2014) may hinder the progress or achievement of the desired learning objectives and are not sufficiently addressed by the TPACK Model.

School policies determine the kinds of technologies and software available to teachers, time allocation for integration, the learner numbers per teacher, access to technical support and finances offered to accentuate the integration of technology into the curriculum. Computing resources and technical support are constraints that may impede teachers from adopting specific ICT tools (Eteokleous 2008). For example, teachers in schools with one-to-one provision of computing devices face design challenges different from those in schools with computer laboratories. Mishra and Koehler (2006) emphasize the consideration of different contextual factors pertaining to the availability of technologies as well as teacher competency

as per the three main knowledge domains, but little attention is paid to addressing neither the widening nor narrowing of the digital divide among different contexts.

In addition, the teachers' attitudes, perceptions and competencies play a role in the willingness of teachers to incorporate technology in their classrooms, and according to Mishra and Koehler (2006), successful technology integration depends on the interplay among content, technology and pedagogy and that teachers' experiences with technology should be specific to different content areas. The model pays little attention to teachers' lack of confidence, negative attitudes towards the use of technology and the teachers' resistance to the need or requirement to integrate new technologies into the classroom.

Furthermore, in an attempt to integrate technology into the delivery of curriculum, there are limitations that are technologically related, such as outdated hardware, lack of appropriate software, and inadequate technical support, which inhibit the process of proper technology integration and the TPACK Model does not adequately articulate such limitations with a well-developed TPACK. In consideration of such possible barriers and limitations associated with the implementation of technologies within the classroom, it is important to alleviate the excessive impact during the planning stage, which is in the teachers' competence with a well-developed TPACK.

3.5. Conclusion

This chapter has implored the combination of Vygotsky's Socio-cultural theory as a theoretical framework and the TPACK theory as the analytical lens through which data gathering and analysis were based. These theories have been complementary to each other. The SCT is a theory that was advocated by Vygotsky whose purpose is to portray the impact of society, culture and history in the teaching and learning space. The main SCT principles that have been employed for this study are social interactions, which involve the exchange of ideas between more knowledgeable and less knowledgeable individuals, and secondly mediation through material tools, symbols and human beings. Lastly, the most popular concept: Zone of Proximal Development: ZPD. ZPD is explained as the imaginary distance

that an individual can reach with the assistance of mediation tools. All these tools are crucial in the learning process and for this study.

TPACK as an analytical theory has been explored for this study and is defined as the knowledge needed by teachers to implement technology integration in their classrooms. The development of TPACK by teachers is critical to effective teaching with technology TPACK theory is claimed to have seven constructs of knowledge which are pedagogical knowledge, content knowledge, technological knowledge, technological content knowledge, pedagogical content knowledge and technological pedagogical knowledge. These knowledge constructs indicate how the interrelation among them may lead to the understanding of teaching with technology. Since this study is premised on the use of gamification technology to support the learning of probability topic, TPACK is fundamental in making sense of the goals, the research questions, findings and analysis in this study.

TPACK as the analytical theory was also debated with its constructs: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK). The justification for using TPACK over other theories was provided. SAMR and TAM were discussed in this chapter as the models that were competitors of the chosen TPACK theory. TAM explicates that the perceived ease of use (PEOU) and perceived usefulness of technology are the main determinants of technology acceptance and therefore are pivotal in the justification of why technology is accepted or rejected.

SAMR was also discussed as the potential theory for this study. The main constructs for SAMR Model are substitution, augmentation, modification and redefinition. All four constructs entail different ways in which technology can be utilized in the classroom. The criticism of both TAM and SAMR models was discussed, and the reasons for not choosing these theories were also debated. Furthermore, the limitations of the TPACK theory were explicated. The next chapter describes the research methodology that will be employed in exploring the research questions.

Chapter Four

Methodology

4.1 Introduction

The previous chapter discussed and presented the theories used in this study, particularly socio-cultural theory and the TPACK framework, as theoretical and analytical frameworks. This chapter serves as a map that depicts methods and techniques used in gathering data for this study and describes the motive behind their choice. Tashakkori and Teddlie (2003) describe the methodology as ways, techniques, or tools for generating accurate and ethical data about a program and techniques, or strategies for manipulating the collected data. According to Cohen, Manion and Morrison (2000), the significance of methodology in a study is to help the researchers understand the processes and products of scientific inquiry.

In cognizance of the above definitions, this chapter explains why this piece of research was conducted and why the methods used were chosen over others. Methodological procedures applied in this study, provision of a detailed account of the research paradigm, research approach, participants and how they were selected and the researcher's positionality are elucidated in order to make sense of the collected data. This resonates with Scotland (2012), who orates that methodology is a plan of action that influences the choice and use of particular methods and is concerned with the steps that researchers can take to find out any kind of knowledge they believe should be made known. This corresponds with Hofstee (2013), who avers that the research methodology gives detail on how the research got to its conclusion. Data generation and methods used to analyse and interpret the data are the main focus of this chapter, and in this piece of research, the methodology section assisted the researcher in understanding all the processes and outcomes entailed in this study.

The methods used to analyse the data are discussed in-depth, and lastly, the issues of validity and reliability, research trustworthiness, triangulation, credibility, transferability, confirmability and ethical considerations are presented in this chapter.

4.2 Research Paradigm

Interpretivism is the paradigm in which this study is underpinned. The main focus of this section is to conscientize the reader about the relevance of the interpretivism paradigm to this study. According to Creswell (2007), a paradigm refers to philosophical assumptions and beliefs that reinforce our choice of theories that guide our research. This is tantamount to Guba & Lincoln (2005), who articulate that a paradigm is a basic set of beliefs that guide our actions. In support of the above definitions, Babbie (2010, p32) also posits that a paradigm is "A frame of reference that we use to organize our observations and reasoning". Therefore, it is crucial for researchers to understand different philosophical perspectives of peoples' beliefs about the nature of reality. Also, researchers need to be aware of their own worldviews based on their ontological, epistemological and methodological assumptions as influential in their way of seeing the world.

Ontology, epistemology and methodology are the basic components of each paradigm. Understanding these components is paramount as they encapsulate basic assumptions, beliefs, norms and values entailed in each paradigm. Creswell (2007) describes ontology as a philosophical standpoint about the nature of existence, what reality is and what people believe reality is. Epistemology is about the process of knowledge acquisition, how we acquire knowledge, how we come to know of something, what counts as knowledge in the world, the nature of knowledge, the way we communicate knowledge to other human beings and the relationship existing between the inquirer and what should be known. Methodology, on the other hand, mirrors how a researcher goes about collecting the relevant data. It involves the designs, techniques, approaches and participants involved during the data gathering process (Cohen, Manon, & Morrison, 2007).

Rehman and Alharthi (2016) indicate that the three most common research paradigms that shape what we see and how we understand what we see are positivism, interpretivism and critical theory. Positivism is characterised by empiricism as it relies mostly on experimentation. Positivists assume that reality is discovered through the use of scientific methods, and there is a single reality which is context-free. Its purpose is to generate numerical data. It is constructed on the premise of a cause and effect relationship between

phenomena; for example, A is the Cause of B. It focuses on measuring, controlling and predicting; hence it is known for generality in that results can be widely applied to other situations, and the reality is assumed to occur independently of human beings and the context of occurrence (Rehman & Alharthi, 2016 and, Cohen, Manon, & Morrison 2007).

According to Cohen et al.(2007), positivism is criticised for not recognising social interactions, individualism and freedom. This is also the reason why positivism was not the best choice for this study. This study focussed on the insights, meanings and experiences of participants from different contexts, and social interactions were key in this study.

The critical paradigm emphasises people's reasoning power which allows them to criticise, challenge and change the nature of society. Cohen et al. (2007) allude to the critical paradigm as transformative as it intends to transform society and individuals. It redresses the inequalities, emancipates the disempowered and promotes individual freedom. The critical theory assumes that reality is shaped by cultural, political, gender and religious factors interacting with one another to create the social system (Rehman & Alharthi, 2016). This paradigm aims to change the world. It was also not relevant as it carries a political agenda which was not the focus of this study.

The interpretive paradigm which was chosen for this study assumes that reality is not discovered but is socially constructed. It is concerned with the voice of the participants. According to Morgan (2011), an interpretivist paradigm is grounded upon the view that social reality is "the product of the subjective and inter-subjective experience of individuals" (p.608). Therefore, according to the interpretivist approach, there is no single truth about the world but multiple realities and the world is understood from the perspective of the participant in action (Morgan, 2011; Bertram & Christiansen, 2017). The emphasis of interpretivism lies on the assumption that realities are socially constructed and are experienced differently by different people from different contexts. Resonating with the above statement, Cohen et al. (2007, pg. 31) state that "social phenomena should be understood through the eyes of the participants rather than the researcher". In addition, Burrell and Morgan (1979) are of the view that the interpretive paradigm "seeks explanation within the realm of individual consciousness and subjectivity, within the frame of reference of the participant as opposed to

the observer of action" (p.28). This expatiates that the interpretations of the individuals about the social phenomena they interact with are more valuable than the interpretations of the researcher in the interpretivist paradigm.

This study's objective was to investigate multiple opinions, understanding, interpretations and experiences of teachers concerning the use of Kahoot! as a gamification technology in the teaching of Probability lessons. It drew meanings, judgements and inferences from the participants' engagement with Kahoot!

Furthermore, this paradigm assisted the researcher in understanding the beliefs and attitudes of teachers towards the use of gamification technology in teaching relative to their historical background and context. Also, compelled by the research topic, the research questions and the nature of the study, the researcher opted for the intervention process through the form of training and practical implementation of gamification in the classroom, which enabled the participants to engage in the process of mediating the learning of Probability mathematics through gamification technology. The participants were actively involved in the process as co-researchers (Scotland, 2012). The goal was to understand and prioritize the participants' insights, concerns and experiences in using Kahoot gamification in their classrooms. According to Rehman and Alharthi, (2016), one of the criticisms of the interpretive approach is that it is not capable of developing theories as it is not generalisable to large groups. The main concern for this study was not for it to be generalised but to focus on viewpoints, feelings and interpretations of the participants about the phenomena studied, and efforts to ensure the trustworthiness of the study were carried out.

4.3. Qualitative Research Design

The research design is pertinent in ensuring accurate collection, analysis and interpretation of the requisite data that is commensurate with the problem at hand. According to Edmonds and Kennedy (2016), the three main categories of research designs are quantitative research, qualitative and mixed-method approaches. Quantitative design examines the difference between quantitative variables. The qualitative approach is based on the assumption that the participants' experiences, behaviours, descriptions and explanations are key in the

construction of social reality. The mixed-method approach means both qualitative and quantitative research designs are employed in research (Cohen, Manon, & Morrison, 2007).

This study is prefaced on the qualitative research design, which embraces the objectives and finds the answers to the research questions related to this study. Qualitative research is premised on the ontological perspective that people are constructors of their own reality through their lived experiences (Cresswell, 2012). This is in line with the interpretivist paradigm discussed above (refer to section 4.2), which maintains that reality is socially constructed. Also, this corresponds with the idea of Greeff, Mulaudzi and Wright (2010), that knowledge in qualitative research is believed to be developed through interaction with others. In qualitative research, the focus is framed in terms of using textual data rather than quantification in the collection, analysis and interpretation of data. This is a type of social science research that depends on words instead of statistical analysis to help us understand the social life of participants in their contexts (Cohen, Manon, & Morrison, 2007; Jackson II, Drummond, & Camara; 2007 & Morgan, 2011). Resonating with the above characteristic of qualitative research, Creswell (2012) articulates that in qualitative research, collection and analysis of linguistic data is done through the use of qualitative methods such as open-ended interviews, open-ended questionnaires, surveys, observations, conversational analysis, diaries, journals inter alia which allow participants to be at liberty in responding to questions without any limitations of static responses hence the qualitative design is known of flexibility.

Qualitative research is characterized by incorporating fieldwork as researchers seek to understand the participants' contexts by physically visiting the research sites to gather information personally. According to Creswell (2013), the qualitative approach implies that the knowledge is constructed in a natural setting, as "qualitative researchers collect data in the field at the site where participants experience the issue or problem under study" (p. 45). Qualitative researchers are primary data collection instruments as their presence is essential in the collection of field-based data. In a nutshell, they submerge themselves in all the data collection instruments and analysis. Qualitative research is exploratory in nature as it seeks to give explanatory answers to 'what', why", and 'how' a particular phenomenon operates the way it does in a particular context (Jackson II, Drummond, & Camara, 2007; Cresswell, 2013).This is due to the fact that the researcher has little control over the context that is being

studied and these questions are meant to allow the researcher to grasp the attitudes, behaviours, perspectives, feelings and experiences of people as they give justified responses that make sense in their own natural setting. Also, the 'what', 'why' and 'how' questions enable the researcher to gain an in-depth understanding of the issue in question.

A qualitative research design was a suitable choice for this study as the researcher was interested in understanding the teachers' points of view about using Kahoot! gamification technology in their schools and to build a holistic picture based on their interpretations and experiences about the phenomenon from their own perspective. This enabled the study to generate meaning from the teachers' experiences, insights and views in using the technology to mediate the learning of probability mathematics in their classrooms. This is tantamount to Scotland's (2012) notion about qualitative research that a phenomenon should be understood from the perspective of the participants. The researcher in this study sought to hear what teachers say and what they do in their classroom settings and to capture an in-depth understanding to the meaning they attribute to the integration of Kahoot! gamification technology in the teaching of the probability topic (Morgan, 2011).

In this study, the researcher employed multiple sources of evidence such as workshop discussions, questionnaires, reflective journals, observations, field notes and interviews to make sense of the collected data. This is in harmony with Gill, Stewart, Treasure, and Chadwick (2008), who elucidate that the use of multiple methods of data collection is another quality of qualitative research. This was done for the purpose of increasing the credibility and validity of the research results.

According to Patton (2015), qualitative research entails a social process between the researcher and participants, which enable the achievement of research goals. The researcher in this study had to get closer to participants and establish a rapport with the aim of getting authentic and rich data. There was direct involvement between the researcher and participants, and the researcher visited the teachers in their respective classrooms for observations and interviews. During interviews, the researcher was able to probe the participants to express their feelings with regard to the implementation of Kahoot! gamification technology in their lessons. The researcher was able to get a glimpse of teachers' and learners' behaviours, the

tone of teachers voices and their body language during the observations and interview processes.

As in all research designs, some criticism has been biased against the qualitative research design. It has been criticised for being unscientific and anecdotal, lacking generalisability and being subjected to bias. Hennik, Hutter, & Bailey (2020), in arguing for qualitative research, stated unequivocally that researchers from the positivist school of thought do not have a deep understanding of the interpretive approach of qualitative design. When a qualitative study is rigorously implemented, it yields credible outcomes. For this study, triangulation of data collection sources was applied to ensure trustworthiness. Also, qualitative studies are criticised for the lack of generalisability. This is because the perspectives of people and their contextualised understanding of phenomena are integral in qualitative studies; hence purposive sampling is commonly used in qualitative research to zoom directly into the contexts that will provide a deep understanding of the issue studied. The sample is always small as in-depth explanations of a phenomenon, and the use of multiple data collection sources are required to achieve the research goals. Although the findings of qualitative studies cannot be generalised, they can be transferred to other similar contexts depending on the level of credibility, dependability and transferability of the study in question. In order to overcome bias, as qualitative studies are known for subjectivity, Hennik, Hutter, & Bailey (2020) suggest that qualitative research aims at studying peoples' lived experiences. The researchers have to understand people in their own contexts and describe their experiences according to the words and concepts used by the participants themselves. In this study, the researcher mostly used verbatim responses from participants when presenting the findings from natural settings.

4.4. Research Approach

This study employed a qualitative case study approach to understanding an in-depth description of how gamification technology could be utilized to facilitate learning in a mathematics classroom. According to Crowe et al., (2011 p.1), "a case study is a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context." This concurs with Teegavarapu and Summers (2008, p.3), who define

a case study “as an empirical research method used to investigate a contemporary phenomenon, focusing on the dynamics of the case, within its real-life context”. This is also supported by Yin (2002, p.13), who avers that a case is “a contemporary phenomenon within its real-life context, especially when the boundaries between a phenomenon and context are not clear and the researcher has little control over the phenomenon and context”. Furthermore, according to Yin (2003) a case study design should be considered when: (a “how” and “why” questions are being posed; when the investigator cannot manipulate the behaviour of those involved in the study; when the researcher wants to cover contextual conditions because of the belief that they are relevant to the phenomenon under study, or when the boundaries are not clear between the phenomenon and context. In addition, Merriam (1998, pp.28-29) “characterizes a qualitative case study as firstly particularistic in that it focuses on the particular situation, secondly, it is descriptive in presenting a thick detailed description of the phenomenon under study and lastly, it is heuristic because it illuminates the readers‟ understanding of the phenomenon under study and it leads to the discovery of new meanings”.

This is relevant to this study as its concern is about how people interpret their reality without manipulating the behaviour of participants as they share their opinions, and the understanding was built on what was heard from the teachers in relation to the use of Kahoot! gamification in teaching and learning. This is tantamount to the advantages of case study research, as Willis (2007) mentioned that the case study allows the researcher to gather in-depth data in a natural setting. It is for this reason that I, as a researcher adopted a case study and qualitative approach to answer the three explanatory research questions on the utilization of gamification in teaching:

- What are the technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a Gamification technology in facilitating learning Probability mathematics learning in rural schools?
- How do Grade 6 teachers make use of Kahoot! to mediate learning of Probability in mathematics subject in rural schools?
- How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers’ pedagogies?

This study complies with the requirements of the chosen approach as it focuses on a single case, the use of Kahoot! as a gamification technology tool to facilitate the learning of mathematics in four schools. The case study approach has got its pitfalls, which were also considered while choosing the appropriate research approach. For example, a case study is criticized for being less generalizable (Massud, 2018). This means that the findings of this study cannot be applicable in other contexts. However, other researchers may be able to make their own transferability judgements which may be based on the credibility and dependability of the study (Lub, 2015).

4.5. Selection of participants

Incorporation of the whole population in a study is not feasible due to time constraints, expenses, accessibility and inadequate resources, therefore, there is a need for the selection of a sample. According to Bertram and Christiansen (2017, p.59), "the word population is used to mean the total number of people, groups or organisations that could be included in a study". This resonates with Welman, Kruger and Mitchell (2011), who articulate that a population is a full set of cases from which a sample can be drawn. On the other hand, sampling refers to the "selection of specific data sources from which data are collected to address the research objectives" (Gentles, Charles, Ploeg, & McKibbon, 2015, p.1775). Patton (1990) advocates that sampling in qualitative research falls under the category of purposeful sampling, a strategy in which particular settings, persons, or events are deliberately selected for the important information they can provide, which other choices cannot. Concurring with Patton (1990), Etikan, Musa, and Alkassim, (2016) define purposeful sampling as a sampling technique that encapsulates a deliberate choice of a participant based on the qualities the participant possesses in relation to knowledge and experience. Furthermore, Patton (2015, p.265) explicates that "the logic and power of purposeful sampling lie in selecting information-rich cases for in-depth study" in order to gain insight and in-depth understanding.

For this study, purposive sampling was adopted to find the category of people who met the criteria crafted by the researcher (**See Table 3**). The researcher selected nine participants and, according to Etikan, Musa, and Alkassim (2016) purposive sampling technique does not have a set number of participants to be selected for a study and maintains that the researcher

sets out to find individuals or groups of individuals that are proficient and well-informed with a phenomenon of interest. The rationale behind sampling nine teachers is that, as the participants have the freedom to withdraw at any stage of the research, the reliability of data will not be compromised, even if some of them may decide to withdraw. The selection of participants was made according to the criteria portrayed in **Table 3.**

Participants	***Number***	***Technique***	***Criteria***
Teachers	Nine	Purposive Sample	. Teachers in possession of a teaching qualification in Mathematics. . Teachers with a minimum experience. of five years in teaching Mathematics' . Teachers teaching Mathematics in Grade Six. . Must be from schools with available technological devices. . Must be in possession of Departmental laptops.

Table 3: Criteria for selecting participants

Nine teachers were selected for being not less than five years' experience of teaching mathematics in Grade 6 in rural primary schools of Amathole East district that are in possession of technological devices to access Kahoot!, which is one of the game-based pedagogical tools (**See Table 3**). This concurs with Creswell (2013, p. 156), who opines that purposive sampling means "the inquirer selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study". Nine teachers, both males and females, from four schools, irrespective of their ICT competency skills, were selected and capacitated on the use of Kahoot! as a gamification technology and later were required to incorporate it in the teaching of Probability using the laptops, tablets and or mobile phones.

Amathole East Education district, whose headquarters is at Butterworth, was established in the year 2017 through the inception of the new organizational structure in the Eastern Cape Department of Education, wherein education districts were aligned according to their district municipalities **(see Figure 3).**

Figure 3: Amathole East District

Amathole East Education district was aligned with Amathole District municipality, which had to be further subdivided into Amathole East and Amathole West education districts due to its vastness. Amathole East district was formed through the amalgamation of two local municipalities, Mnquma and Mbashe (**see Figure 3**). It is comprised of six circuit management centres, of which three belong to Mnquma municipality i.e Butterworth, Centane and Nqamakwe CMCs, and the other three falls under Mbashe municipalities, namely Dutywa, Willowvale and Elliotdale and they are all aligned according to the magisterial districts.

The table below shows the biographical information of each participant in the study

Teacher (Pseudonym)	Gender	Age	Teaching Experience	Qualification
Teacher 1	Female	49	28	STD Mathematics & Science, ACE Mathematics
Teacher 2	Male	31	5	B.Ed. Mathematics.
Teacher 3	Female	40	14	Advanced Certificate in Education (Mathematics)
Teacher 4	Male	43	19	B.Ed. Mathematics
Teacher 5	Female	44	12	B.Ed. & PGCE Mathematics
Teacher 6	Male	48	24	B.Ed. Honours: Mathematics
Teacher 7	Female	47	11	Senior Primary Teachers Diploma (SPTD)
Teacher 8	Female	42	16	Advanced Certificate in Education (Mathematical Literacy)
Teacher 9	Male	33	8	B.Ed. Mathematics

Table 4: Participants' biographical information

4.6. Site and accessibility of the study

The study was conducted in each of the four schools selected in two Circuit Management Centres (CMCs), Butterworth and Dutywa sub-districts that belong to Amathole East Education District in the Eastern Cape Province. The criteria for choosing these schools were based on the availability of ICT resources that could be used by teachers and learners to access Kahoot! Gamification technology. Three schools were the beneficiaries of the Thabo Mbeki Foundation Digital Initiative, which provides twenty-five primary schools in the district with a tablet solution for teaching and learning, and one selected school that was not

participating in the project had got its own ICT devices. The school should have access to the Internet. The selected schools should have the intermediate class of Grade 6 and be in possession of a Mathematics teacher/s for this Grade. Schools were also selected on the basis of closer proximity to the District ICT Centre, where collective training of the selected teachers on gamification took place and also for easy access by the researcher. The reason for choosing four schools was to ensure the reliability of data even when some participants withdrew from the study.

4.7. Researcher Positionality

According to Marvin (2019), positionality refers to the 'stance or positioning of the researcher in relation to the social and political context of the study, the community, the organization or the participant group'. In addition, Arora et al., (2017) expound that the opinions, values, beliefs, and social background of the researcher influence the research process, shaping of methodological and analytical decisions that he or she makes. The researcher was cognizant of the effects that her positionality as e-Learning Coordinator in the Education District office could have on the nuances of power dynamics and the teachers' interaction during the research process, this could have influenced the way participants interacted with the researcher during the research process. However, this was mitigated by addressing power dynamics, being reflective throughout the research process to identify, construct and critique the researcher's position, and instead of shaping the research process, the researcher allowed to be shaped by it and the participants (Cohen et al., 2011). According to Bourke (2014) positionality is a space in which objectivism and subjectivism meet, and researchers cannot divorce themselves from subjectivity; therefore, in striving to remain objective, they need to be mindful of their subjectivities and acknowledge who they are as individuals and as members of groups, and also within social positions. In this study, the researcher introduced herself as a co-researcher and a co-learner and worked together with the participants to learn how to use Kahoot! and to explore if Kahoot! could support the learning of probability. The researcher was transparent about the purpose of the study and fostered openness among the participants. A good rapport was established, the participants' confidentiality was assured and the findings would not be shared with their supervisors. Also, pseudonyms have been used during the write-up and presentation of selected responses of the selected participants in this

thesis (Bourke, 2014). Furthermore, the participants were made aware of their freedom to choose not to participate or withdraw at any stage of the research process without any impact on their employment. The participants were therefore thoroughly orientated that they were not compelled to participate and their withdrawal would not negatively affect their work relations with the researcher.

4.8. Data gathering techniques

In line with Yin (2009), who advocates for the use of a variety of data collection procedures in a qualitative study, the researcher opted to use workshop discussions, semi-structured questionnaires, semi-structured interviews, non-participant observations, document analysis and reflective journals. Each candidate was subjected to all data generation tools, except for six participants who were selected for semi-structured interviews and observations. The main aim of this allocation was to ease the burden on participants without compromising the validity of the study.

4.8.1. Workshop Discussions

According to Asraf (2018), workshops are teacher education and professional development programmes which foster engagement through collaborative discussions and constructive feedback between the participants and facilitator. In addition, Ørngreen and Levinsen (2017) explain a workshop as "an arrangement whereby a group of people learn, acquire new knowledge, perform creative problem-solving, or innovate in relation to a domain-specific issue" (p.71). The notion of workshops comprehends Vygotsky's (1978) concept of social interactions in which knowledge construction originates through collaboration between more knowledgeable and less knowledgeable others. For this study, two workshops were conducted by the researcher at the education district office computer laboratory with all nine participants. All precautions to adhere to COVID-19 protocols were considered. The main objective of the first workshop was to train teachers on how to use Kahoot! gamification technology to mediate the learning of probability in Grade 6 Mathematics. Teachers were afforded the opportunity to collaborate and work together, having their own understanding and interpretations about the use of Kahoot! During the workshop, the researcher presented to

teachers taking them through what gamification is, designing, playing and accessing reports in Kahoot! and how it originated. Then the researcher started by showing teachers how to create a game and shared the website https://create.kahoot.it/login. When streamlining the searching to Grade 6 Probability Kahoots in order to access the pre-existing quizzes, a screen with more options to choose from appears **(see Figure 4).**

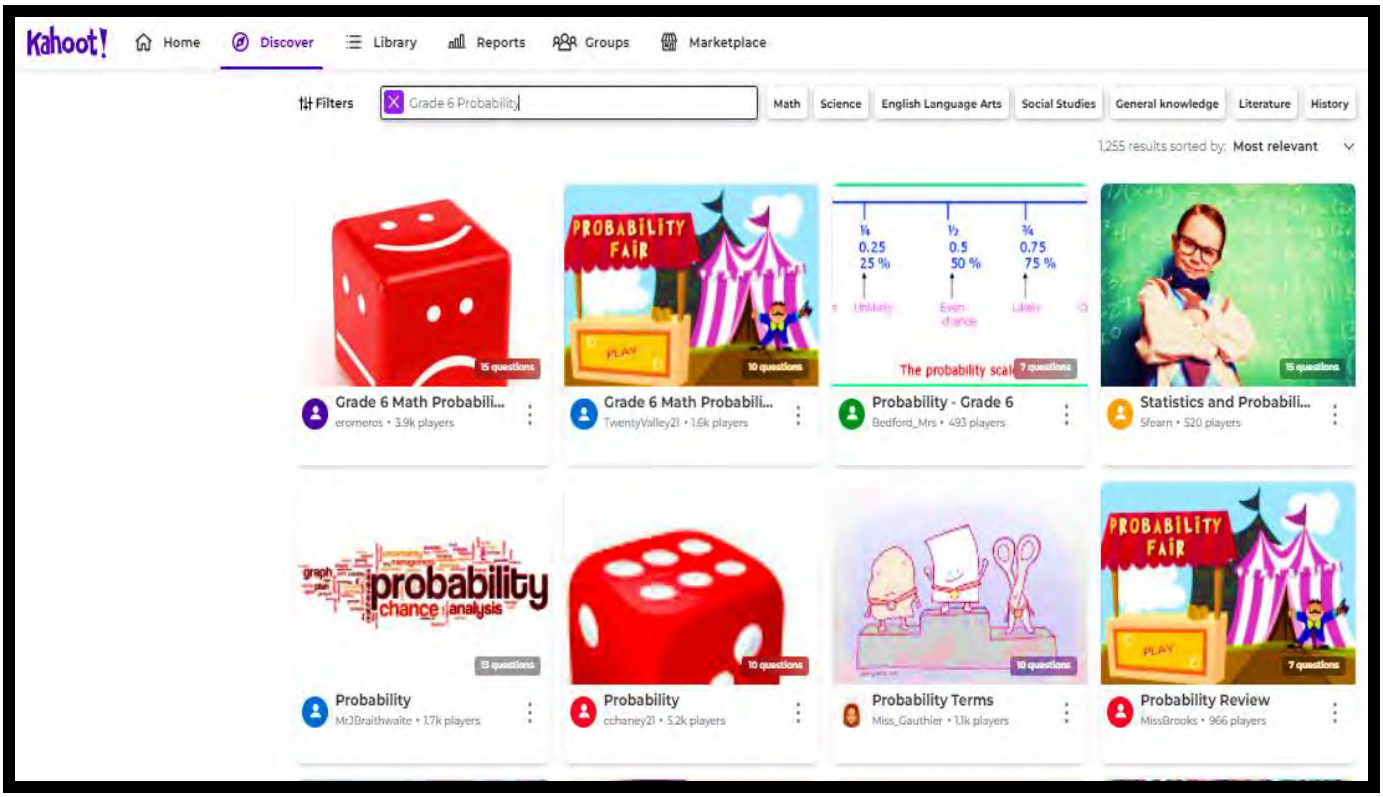


Figure 4: Kahoot interface

The participants had to join the leader's game as learners at first to see and feel how this technology works. In order for teachers to join as learners, they had to go to a browser and enter the URL: https://kahoot.it, and a screen that allowed them to enter the game pin appeared and the pin was given on-screen by the researcher and they were ready to start playing the game. They enjoyed the game and were then eager to know how to create a game for their learners. This is evident in the journal entries as one participant stated, '*I have found Kahoot! very interesting and I will give it a try with my learners, hoping that my classroom*

will never be the same again'(T1RJ). In unison (T7RJ) commented that, '*I wish I had known Kahoot1 earlier than now, I spent all my years trying every trick in the book to inspire learners to love mathematics, if Kahoot! has stimulated so much interest in me, how much more with my learners*'. Correspondingly, T8RJ remarked that '*On the night of the Kahoot! workshop I kept on looking at the clock as I was eager and excited to go back to my learners to introduce this new technology, it was as if I was born again*'

Teachers were trained on how to enter the URL for creating the game on the browser and were made to first sign up before logging in. They got enough time to take turns creating the games and others had to play as learners. They were shown how to choose from pre-existing games and customize those for their learners' levels. Having mastered that part of the workshop, the participants engaged in serious and vibrant discussions. The discussions were recorded in the researcher's journal. In the discussions, participants also touched on the enabling and constraining factors for their own contexts. Teachers as participants shared their technological and pedagogical experiences and insights and these were documented and assisted in responding to research questions one and question three. Furthermore, Vygotsky's (1978) concepts of social interactions, mediation and ZPD were observed as the participants were guided on the use of Kahoot! Also, in the first workshop, the researcher explained the steps to follow after the workshop. The participants had to be subjected to questionnaires, workshops, journals of reflection, observations and interviews as data-gathering instruments. The second workshop was held to reflect on the experiences of practically using Kahoot! gamification technology in the teaching of probability, and therefore the two workshops offered responses to address research questions one, two and three.

4.8.2. Semi-structured Questionnaires

A questionnaire is a self-report data gathering tool consisting of a set of questions that respondents complete on their own or in the presence of the researcher as part of the research study to elicit information about thoughts, feelings, perceptions, opinions, beliefs, attitudes, values and behavioural intentions of the participants (Adejimi, Oyediran, & Ogunsanmi, 2010; John & Rule, 2011; Zohrabi, 2013; Bertram & Christiansen, 2017).

A semi-structured questionnaire is a questionnaire that asks both closed-ended and open-ended questions. Closed-ended questions are those comprising of response options from which the participants should choose, while open-ended questions are those without predetermined responses and participants are required to freely give many details in their answers (Bertram & Christiansen, 2017). In order for this study to address the first research question, a semi-structured questionnaire was administered to all nine participants just before the training of teachers took place to understand the teachers' prior technological experiences and pedagogical insights on the use of Kahoot! and other technologies in teaching. The questionnaire was sent to participants via email, and they were expected to send it back before the workshop, but only six out of nine sent back the questionnaires, and the other three participants brought theirs on the day of the workshop and as such, I witnessed one of the drawbacks enunciated by Cohen et al. (2011) and Bertram and Christiansen (2017), that mailed questionnaires are not easily returned by participants. I opted for the semi-structured questionnaire to allow the respondents to write openly about their opinions and experiences pertaining to their use of gamification technology. This information assisted in preparation for the training and to address the first research question. **(See Appendix A)**. In addition, the researcher ensured that the questions were in a simple English language that was understandable to participants and ambiguous questions were avoided (Cohen et al., 2011). The questionnaire was then piloted on two intermediate-phase mathematics teachers who were not part of the sample and were from other schools outside the research site (Kabir, 2021).

4.8.3. Semi-Structured Interviews

An interview is a form of qualitative data collection technique involving interpersonal questions based on a verbal interchange of views orchestrated and directed by the researcher/interviewer to explore the respondents' perspectives on a particular phenomenon (Lichtman, 2009; Alshenqeeti, 2014). There are three types of interviews that are frequently employed in social sciences: structured interviews, unstructured interviews and semi-structured interviews (Kabir, 2021). The structured interviews comprise pre-determined standardized questions that are consistent from one interview to another. This type does not require the establishment of a rapport and gives consistent results that can be compared across participants. The limitation of structured interviews is that they are rigid and are influenced by

the researchers' bias (Qu & Dumay, 2011; Alshenqeeti, 2014). An unstructured interview is open-ended, flexible and interviewee driven as no questions are prepared in advance by the interviewer. The interviewer's major responsibility is to establish a good rapport for the interviewee to feel at ease to reveal real-life experiences and complex social reality (Kabir, 2021). Additionally, a semi-structured interview is characterized by flexibility in that the researcher is able to allow unexpected information to emerge, and also standardization is evident as it also follows strong patterns. This type of interview permits the researcher to probe in order to expand the interviewees' responses (Qu & Dumay, 2011).

The preferred interview type in the present study was semi-structured to complement the data obtained through workshops, questionnaires, observations and reflective journals. The selection of participants was the first step taken by the researcher, as Bolderston (2012) alludes that the first step in the interview process is the selection of participants and that participants are selected according to the intention of the research. Five participants were interviewed. All the five interviewed participants were selected using the criteria: actively engaged in all the two workshops, had written all the required reflective journals and volunteered to be observed as they taught the Probability lessons using Kahoot! gamification technology. The interviewees were required to have conducted the Kahoot! lessons in their own classrooms before being subjected to interviews. The interview questions were pre-planned, and a paper-based interview guide with open-ended questions was developed **(see Appendix D)**. The interviews took place in arranged school offices where the researcher and the interviewee shared a quiet and private space. Rapport was established and questions were asked by the interviewer allowing the respondents to freely respond to the questions with more detail (Cohen, Manon, & Morrison, 2007). Questions were posed, rephrased, clarified and translated where necessary. Spontaneous questions were asked to probe the interviewee to elaborate on original responses. Although the researcher took some notes, all the interviews were audio-recorded, and later transcriptions from the original recordings were done, printed, and coded and themes and categories were identified (Cresswell, 2007). Even though semi-structured interviews were found to be the appropriate option for this study, some limitations were noted. For example, they were much more time-consuming than other data collection methods used. It was not easy to establish uniformity across the respondents. Through

interviews, teachers were able to provide detailed information from their own context on how gamification technology had or had not assisted them in the teaching of Probability (Foundation, 2019). Semi-structured interviews assisted in giving the response to all three key research questions of this study.

4.8.4. Observation

The 'observation' was employed in tangent with other data collection techniques in this study. According to Creswell (2013, p.166), observation is a fundamental way of witnessing first-hand information about the phenomenon of interest in the site of study through watching 'physical settings, participants, activities, interactions, conversations, and your own behaviours' as the researcher, engaging the five senses including sight, hearing, touch, smell, and taste'. This notion is supported by Cohen et al. (2007), who posit that observation involves the collection of live data from a natural setting. For this study, the researcher studied the participants' behaviour right inside their classrooms in natural settings, watching the use of Kahoot! gamification technology and other aspects that the participants might not be able to reveal in other data collection methods employed. Out of the different observational methods that have been described by Kabir (2018), the participant and non-participant observational methods attracted the attention of the researcher. In participant observation, the observer takes the role of an insider being immersed in the participants' activities taking place in the field (Cooper, Lewis, & Urquhart, 2020). Non -participant observation is when the researcher takes the stance of being an outsider and observes without any involvement in the interactions of the participants in the field. In this study, the researcher opted for non-participant observation and had to be unobtrusive without interfering with any of the activities that took place in the classrooms. This enabled her to have access to the information and non-verbal expressions that the participants could not reveal; as postulated in Kawulich (2015 p.6) that observation enables the researcher to access " backstage activities that the public does not generally see".

The researcher made appointments with the participants and the gatekeepers for observation sessions. This enabled her to observe the teacher-learner interactions inside the classrooms as natural settings. The researcher opted to stay in the background retaining the position of an

outsider making sure not to be immersed in the interactions that took place and recording detailed field notes (Ciesielska & Jemielniak, 2016). The designed observation tool assisted in generating data on teachers' technological and pedagogical knowledge, thus addressing questions two and three of the research questions (**see Appendix C**).

There were limitations encountered during the use of the observation technique in this study. The presence of the researcher may have influenced the participants' actions and as such, the participants acted differently as they were aware that they were being observed, which means that their behaviour was somehow orchestrated to meet the demands of research. In addition, for this study, there are no prescribed guidelines on the use of Kahoot, except that the participants were orientated during the workshop, also, the programme is learner-centred and the means to control the learners' emotions are limited. The issue of observer bias is another limitation. Kabir (2021) avers that observer bias occurs when observers are selective on which behaviours they choose to observe, leading to systematic errors. In this study, the observer bias was overcome by being aware as a researcher that bias may prevail in the field. In addition, field notes were carefully recorded and an observation guide was used wisely.

4.8.5. Reflective Journals

Journal writing is another data collection method that was employed in this study through the random selection of three out of nine participants and myself, as a researcher, to ease the load without compromising the triangulation process. According to Holsblat and Bashan (2017), journals are tools for the improvement of learning as they integrate theory and practice. In line with this opinion, journals were recorded in this as they were participating in all research activities. The aim was to enable the researcher and participants to interpret their individual actions by looking at themselves and considering the way of changing so as to improve their teaching practices. Dunlap (2001) suggests that reflective journals have a dual purpose of capturing and tracking learners' changes as well as reflecting on their learning and accomplishments. The reflective journals for the researcher as well as for teachers based on the experience of utilizing gamification technology in teaching Probability were used as data sources for this study to record changes and to reflect on accomplishments. This is also supported by Burk & Olsen (2014), who articulate that a reflective journal assists learners in

expressing and evaluating their experiences and assessing their personal growth. The study employed reflective journals as a method of collecting data because of their potential to allow participants to reflect on their feelings, insights and experiences pertaining to their progress towards the integration of gamification technology into curriculum delivery (**see Appendix B**). Although journals were used, it was observed that the information was not enough because some teachers chose not to frequently write journal entries due to time constraints and procrastination. Journals by teachers and the researcher were used in this study to assist in addressing research questions one, two and three.

4.8.6. Document Analysis

The review of printed and electronic documents was paramount for this study. According to Bowen (2009, p.27), data is examined "in order to elicit meaning, gain understanding and to develop empirical knowledge". For this study, the document analysis was not used as a data generation tool but as a guide to approach the workshops and solicit the subject guidelines. For example, Kahoot! as a tool was administered in the curriculum to support the learning of Probability, and analysis of Curriculum and Assessment Policy Statement (CAPS) documents assisted the researcher in noting the stipulations of time and content that should be covered, specific to grade six mathematics with special consideration to the topic Probability. The time allocated for Probability lessons as a topic, as well as the academic year term in which this topic should is taught and the depth of the content, was revealed through document analysis. The examiners' reports for 2017 and 2018 were consulted and they influenced the formulation of the topic for this study. Other documents examined were: White Paper 7 of 2004 and Action plan 2014 towards the realization of schooling 2025, which assisted the researcher in determining the extent to which teachers should engage with ICT in classroom practice. This notion is supported by Bowen (2009), who alludes that the documents allow researchers to reveal the meaning and have understanding and insights relevant to the research problem. The research problem and data generation methods for this study have been influenced by the analysis of the documents reflected above. Also, the study's data was validated and corroborated through data obtained during the documents' analysis (Bowen, 2009). This was cost-effective as the researcher managed to retrieve some documents from the Internet and access others in the archives of the department of education (Bowen, 2009). The researcher

was also mindful of the limitations of document analysis, as cited by Yin (1994), that the documents may contain insufficient information and their selection may be influenced by the researcher's bias and for this study, relevant documents were carefully selected.

4.8.7. Triangulation

The triangulation method was employed to ensure credibility and trustworthiness and validate the methods used to collect the data in this study. Patton (1999), alludes that triangulation involves the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena and that each method reveals different aspects of empirical reality to provide more grist for the research. A qualitative study allows a number of data collection techniques to be used either singularly or in combination based on the type of data required and interpersonal contact between the participants and researcher or, in cases of observation, the presence of a researcher in proximity to pertinent events is imperative to ensure validity and trustworthiness of the research (Cohen,2007).

Concurring with Cohen (2007), this study engaged in a wide range of data gathering methods: questionnaires, workshop discussions, interviews, observations, document analysis and reflective journals to ensure the validity and trustworthiness of this study. Also, the interpretive paradigm and the qualitative case study approach chosen for this study allowed the use of triangulation.

4.9. Qualitative Data Analysis

The previous section dealt with how data was generated. This section discusses how the research data collected through the implementation of techniques had undergone a process of being examined, analysed and interpreted in order to make sense of the data with the intention of ensuring the trustworthiness of findings appropriate in answering the research questions. Data analysis is the most crucial and complex part of the research, which requires the researchers' application of analytical and logical reasoning to determine the patterns, relationships and trends that emerge from the collected data (de Casterle, Gastmans, Bryon, & Denier, 2011). Creswell (2013) refers to data analysis as a process that "involves organising the data, conducting a preliminary read through database, coding and organising

themes, representing the data and forming an interpretation of them" (p.179). Likewise, Cohen et al. (2018) define data analysis as a process of encapsulating, organising, explaining and reducing data to make sense.

Creswell (2013) alludes to qualitative data analysis as a process of describing, classifying and connecting phenomena with the researcher's concepts. Reduction of abundant amounts of written data and identification of manageable and comprehensible themes are key elements of qualitative analysis but should be performed in a way that attempts to respect the quality of the qualitative data (McMillan & Schumacher, 1967). Therefore, this section outlines the processes that were followed to make sense of the gathered data. According to Maxwell (2008), data analysis should be conducted simultaneously with data collection. For this study, preparation for data analysis was made even before the actual data collection. This is congruent with John & Rule (2011), who suggests that a system for organising data should be developed prior to data collection. A system of data analysis was in place before collecting data to ease the pressure of the analysis process. In this study, the researcher started by coding the data sources, participants and institutions to ensure anonymity and confidentiality and pseudonyms were given to participants' institutions as highlighted in the ethical considerations. Data sources were coded according to the **Table 5** below:

Data source	**Code**
Teacher Questionnaire	T1-Q…… T9-Q
Teacher Interview	T1-I -T5-I
Personal Reflective Journal	PRJ
Teacher Reflective Journal	T1RJ -T9RJ.
Observation	T1O- T5-O
Documents	D1……D5

Table 5 : Coding used for data sources

In addition, the participants and their institutions were coded as shown in **Table 6** below:

Participant	School
T1	Miracle Primary School
T2	Miracle Primary School
T3	Miracle Primary School
T4	Perfect Senior Primary School
T5	Perfect Senior Primary School
T6	Solution Primary
T7	Solution Primary
T8	Xolovane Primary
T9	**Xolovane Primary**

Table 6: Participants and their schools (Pseudonyms)

The collected raw data was scanned and stored securely in Google Drive, a free cloud-based storage service that enables users to store and access files online, whilst the hard copies were filed and stored in a lockable cabinet.

The thematic analysis approach was found to be the most appropriate approach for this study as it is a process of identifying themes organising, analysing and presenting patterns within qualitative data (Alhojailan, 2012). Interviews and classroom observations were recorded and transcribed. Much time was spent reading and re-reading the transcripts to get a deeper understanding of the collected data. I learned that it is not easy to analyse written data as there is no one way of analysing qualitative data, and it is mostly learnt by doing (Patton, 2002).

The transcribed data was closely examined and inductively analysed to find constructs, themes and patterns. The inductive analysis approach ensured that the themes emerged from the collected data. A process of coding in which small pieces of data were identified and grouped according to their similarities, thus allowing themes and sub-themes to emerge from the collected data in a procedure called categorisation (Cohen, Manon, & Morrison, 2007), was followed in this study. This procedure is commensurate with the grounded theory as it

advocates for the theory developed from data and which is systematically gathered and analysed through the research process (Glacier and Strauss, 1967).

As the patterns became visible, the interpretation of data became more organised and structured and gradually, the triangulation of other data sources such as the questionnaires, journal reflections, and workshop discussions were pursued. Although data analysis was conducted using the inductive method, the identified codes were also influenced by the research questions asked in the review of the literature and the theoretical framework underpinning this study.

4.10. Trustworthiness in the collection and analysis of data

Trustworthiness is a salient aspect of qualitative research, and therefore it is the obligation of every qualitative researcher to ensure that his/her research is recognised and understood as legitimate by other researchers, practitioners, policymakers and the public. Qualitative and quantitative designs use different approaches to determine the quality and acceptance of the research results in the scientific arena. For quantitative research, validity and reliability are crucial elements in assessing the quality and integrity of the research. Validity is explicated as associated with the appropriateness of the research instruments and whether they measure what they intended to measure (Golafshani, 2003). On the other hand, reliability is defined as the extent to which the research findings are replicable given the same instruments, same setting and same participants. It refers to the consistency of results when repeated over time (Bertram & Christiansen, 2017; Md.Ali & Yusof, 2011). Some qualitative researchers challenge the relevance of the two concepts, reliability and validity, in qualitative research stating that the two are consecrated concepts for quantitative research and that qualitative research should be judged in its own terms as it is tangled with multiple perspectives based on data gathered from different participants viewpoints (Hayashi Jr, Abib, & Hoppen, 2019). This notion is supported by Cutcliffe and McKenna (1999, p.376), who asserts that "qualitative studies should be judged using criteria that are developed for and fit the qualitative paradigm". Onwuegbuzie and Johnson (2006) advocated for replacing the concept of validity with trustworthiness for suitability in a qualitative paradigm. Lincoln and Guba (1985) proposed the criteria to evaluate the trustworthiness of qualitative study as

encapsulating credibility, confirmability and transferability, which is parallel to the quantitative assessment criteria of validity and reliability. Taking cognizance of the above proposal, the researcher aligned herself with the criteria by Lincoln and Guba(1985) to ensure the trustworthiness of this study.

4.9.1. Credibility

Credibility is the degree to which the research findings represent plausible information gathered from the participants' original data and the interpretation by the researcher (Korstjens & Mose, 2018). It corresponds with the concept of internal validity that is mostly used in the quantitative perspective, which refers to the extent to which the observed results represent the truth in the population studied (ibid). To ensure the credibility of this study, the researcher engaged in strategies proposed by Lincoln and Guba (1985) and Cresswell (2007), which could assist in increasing the trustworthiness. The first one is triangulation: The researcher engaged in a number of data collection techniques such as workshop discussions, semi-structured questionnaires, semi-structured interviews and journal reflections to solicit answers to the research questions. The second one is observations: the Kahoot! lesson observations were done at three sites. Another strategy pursued to guarantee credibility was member checking: the researcher went back to participants with transcribed data from the interview recordings, findings of the study, interpretations and conclusions so that there could be a level of agreement between the participants and the researcher on the outcomes of the study. Another step that the researcher engaged in was the issue of clarifying the possible researcher bias: just to remind the reader, the issue of researcher positionality was revealed in this chapter. As Lincoln and Guba (1985) reflected that not all of the credibility strategies might be suitable in a study, the researcher determined the strategies that were appropriate for

this particular study.

4.9.3 Confirmability

Confirmability is the crucial criterion to which a research study has to adhere in order to increase its trustworthiness. Confirmability in qualitative research is established when credibility, dependability, and transferability have been achieved, meaning that it is the last

criterion of trustworthiness to be established. According to Lincoln and Guba (1985), confirmability is the degree to which findings of the study could be confirmed by other researchers. This notion portrays that confirmability is associated with the level of confidence that other researchers may have in the research findings. The findings and interpretations of this study were deduced from the generated data as supported by Korstjens and Mose (2018), who advocate that the findings and interpretation should be grounded on data. The findings of this study were based on the opinions and experiences of the participants rather than the researcher's point of view. The documentation of every procedure undertaken was key for constant examination and scrutiny in an attempt to achieve confirmability.

4.9.4. Transferability

Transferability is the extent to which the research findings have a potential for extrapolation to other contexts or settings with other respondents (Satu et al., 2014). Also, Lorelli, Norris, White, and Moules (2017), resonating with Lincoln and Guba (1985), suggest that it is the duty of the reader to make judgements and assess the transferability of the research findings to their own contexts. The role of the researcher is to provide clear descriptions of participants and the research process so that those willing to transfer findings to their own contexts are able to assess the transferability opportunities of the study in question (Korstjens & Mose, 2018).

In this study, an effort was made to describe who the participants were and the criteria for their selection, as well as the research strategies used and how users were they used and how the data was analysed to enhance transferability. The researcher had consulted similar studies conducted in other contexts and future researchers could further conduct studies similar to this one in their contexts as well.

4.10 Ethical Considerations

This study involved human participants and therefore, the researcher was ethically obliged to ensure that they are protected as a directive for all research involving human subjects (Siti, 2018) through adherence to ethical guidelines.

The researcher had to seek ethical approval and access to sites and participants prior to conducting this study. The ethics approval was sought and granted by the Rhodes University Ethics Committee (REC) (**see the ethical certificate Appendix E).** Also, as this study was conducted in public schools, permission was granted by the Department of Education in the Eastern Cape Province (**see Appendix F**) and was shared with relevant stakeholders such as the Cluster Chief director, the District Director, CES Curriculum and principals, before the study was undertaken. The researcher went to each of the four schools to request access and permission to conduct a study, and letters to school principals to request access were submitted (**see Appendix G).**

In addition, the researcher obtained informed consent and voluntary participation among the sampled participants, Grade 6 Mathematics teachers. Participants were approached individually and the purpose of the study and the process of collecting data was fully explained. The participants were given time to ask for clarification and voice their concerns. They were informed that their participation was voluntary and that they had the freedom to withdraw at any given time. The researcher had to allow participants to decide whether to participate or not in the study (Bertram & Christiansen, 2017). Participants' consent in this study was obtained and a letter of written informed consent outlining all the processes and procedures to be followed was discussed and signed by each participant (**see appendix H).**

Furthermore, the issue of anonymity and confidentiality was preserved as the identity and names of participants and their schools were not revealed in the processes of data collection, analysis and reporting of the findings, tantamount to the articulation of Cresswell (2013) that it is the ethical responsibility of the researcher to protect the anonymity of the participants. The interview sessions were held in privacy and confidentiality was carefully taken care of.

Another important issue to consider is whether the research is of benefit to the participants, other researchers or society as a whole. This research study was of benefit to the participants and the society because it orientated teachers on a different strategy of teaching Probability.

4.11. Conclusion

This chapter outlined the methodological approach and research design that was explored in this study, being underpinned within the interpretive research paradigm by means of a case study approach. It provided every step taken in the research process to reach the outcome of this study. The research questions assisting in answering the overarching question were stated. This was followed by a clear discussion of the sampling technique used in the selection of participants. The research site and accessibility, as well as the positionality of the researcher, were detailed. The data gathering techniques, namely, the semi-structured questionnaires, journal reflections, observations and semi-structured interviews and the rationale behind such choices were outlined. Data analysis was also made explicit. Trustworthiness of this study with a focus on credibility, dependability transferability, and confirmability was addressed. Furthermore, this chapter made reference to how ethical principles were adhered to. The techniques discussed in this chapter assisted in obtaining the findings of the current study that are presented in the succeeding chapter five.

Chapter Five

Results of the study

5.1. Introduction

The previous chapter explored the methodological procedures applied in this qualitative case study, providing a detailed account of the research paradigm, research approach, participants and how they were selected. It gave a comprehensive description of what was being investigated and why. What, how, why and when the data gathering instruments were administered. This chapter presents and analyses the findings obtained through the application of semi-structured questionnaires, workshop discussions, journal reflections, lesson observations and semi-structured interviews as the data sources that assisted the respondents in expressing their perceptions and experiences from their own perspectives. The findings presented in this chapter emanated from the collected data. Just to remind the reader, the purpose of this study was to find out how Kahoot! as a gamification technology in teaching, can support teachers to facilitate the learning of Probability. This chapter started with findings based on the biographical information on the questionnaire, which was captured on an excel spreadsheet before it could be analysed. The rest of the findings from the questionnaire and other sources were structured according to the research questions that were asked in chapter two.

5.3. Data presentation and analysis

To make sense of the generated data, the results were organised according to the three research questions that guided the process.

1. What are the technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a Gamification technology in facilitating Probability mathematics learning in rural schools?
2. How do Grade 6 teachers make use of Kahoot!
3. How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?

5.4. Research results

5.4.1. Personal characteristics of research participants

This section presents five personal characteristics: gender, age, teaching experience, grades taught and the highest qualifications that were taken into consideration during the data generation process as they play a pivotal role in the teachers' technological experiences and pedagogical insights. It is stated in chapter 4 **(See Table 2**) that nine teachers from four schools participated in the study. Out of nine respondents, five of them were females and four of them were males (**see figure 3**).

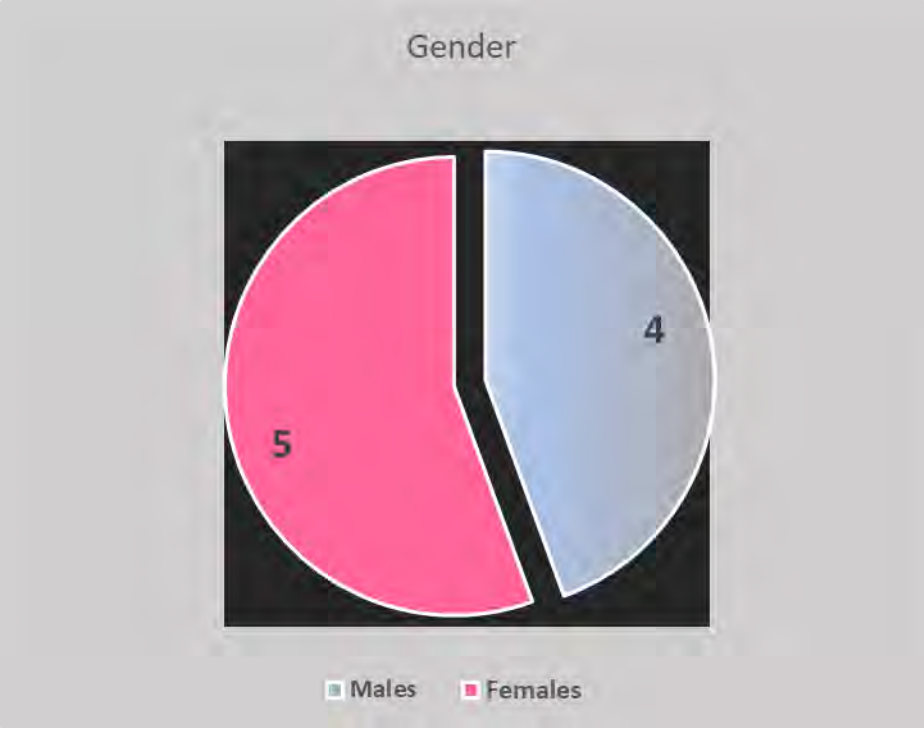


Figure 5: Gender

The second biographical question was based on the age of the participants, followed by their experience. The responses revealed that the age of the respondents ranged between 31 and 49. Their experience in teaching was from eight years right up to twenty-eight years. It is noticeable that the number of years in teaching correlates with the age of the teachers; the younger the age, the lower the experience and the older the age, the higher the experience (**see figure 4).** The teaching experience of all the participants ranged from five years and above.

Figure 6: Age and experience

Overall, nine teachers participated in the study. All of them were qualified mathematics teachers with their highest qualifications above the matric level. One had the Senior Primary Educators' Diploma in Mathematics and Sciences, two had Advanced Certificate in Education (ACE) in Mathematics, one had ACE in Mathematical Literacy, three were in possession of a Bachelor of Education degree in Mathematics and one had B.Ed. Honours in Mathematics and the table below represents the participants and their qualifications

(**See Table 7**).

T1	T2	T3	T4	T5	T6	T7	T8	T9
ACE Math.	B.Ed. Math.	ACE Math.	B.Ed. Math.	PGCE Math.	B.Ed. Honours: Math.	SPTD Math. & Science	ACE Math. Literacy	B.Ed. Math.

Table 7: Highest Qualifications

The fact that the participants of this study have their qualifications in mathematics assists the researcher in understanding that the teachers are in possession of pedagogical and content knowledge, which according to TPACK theory, is important in the integration of technology once the technological knowledge is acquired.

The figure below portrays the number of grades taught by each participant. Five of the participants were teaching two Grades, one participant taught one grade, one taught three grades and two others were teaching four Grades (**see figure 5**). The information on the number of grades taught by participants enables the researcher to know how much teaching load is bestowed upon each participant. When participants are overloaded with teaching, they may not make time to integrate technology into teaching and learning. The majority of participants seem not to have a huge load even though the questionnaire did not ask the number of learners or classes taught per grade. Two participants taught more than three grades, meaning that their workload is higher than other participants who taught between two and three grades each.

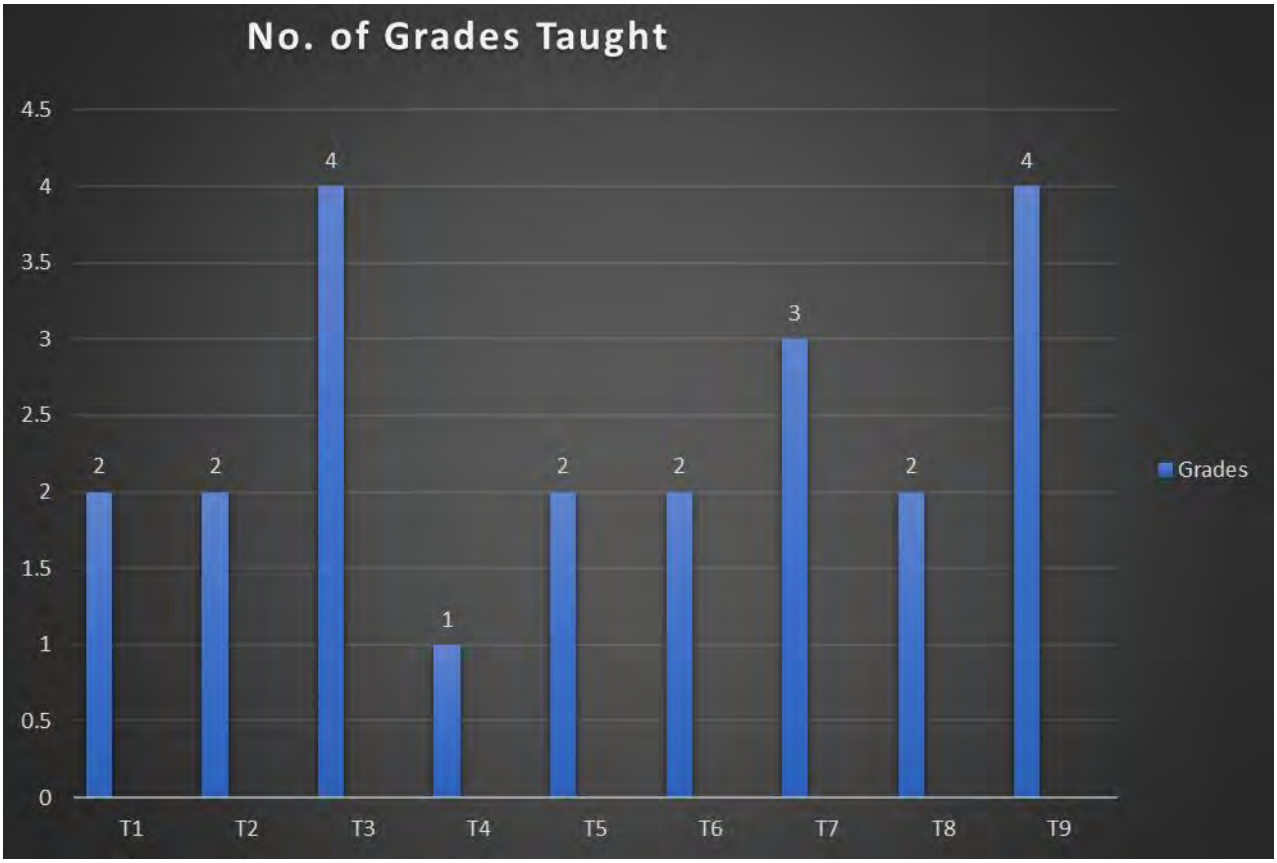


Figure 7: Number of Grades Taught

The table below shows the participants and their schools. As stated in the ethical considerations of this study (**Chapter 4, 4.10**) that anonymity and confidentiality were preserved, and the identity and names of participants and their schools were not revealed in the processes of data collection, analysis and reporting of the findings. Teachers were instead addressed as T1-T9 and pseudonym names were given for their schools (Creswell, 2013) **(see Table 8 below)**.

Table 8: Participants and their schools (Pseudonyms)

Participant	School
T1	Miracle Primary School
T2	Miracle Primary School
T3	Miracle Primary School
T4	Perfect Senior Primary School
T5	Perfect Senior Primary School
T6	Solution Primary
T7	Solution Primary
T8	Xolovane Primary
T9	Xolovane Primary
Total = 9 teachers	**Four schools**

5.4.2. Research Question 1: Technological experiences and pedagogical insights on the use of Kahoot!

The teachers' technological experiences and pedagogical insights could assist in a better understanding of how prepared teachers were to adopt the integration of Kahoot gamification into the mathematics classroom practice. According to Schmidt et al., (2014) it is necessary to have knowledge of various technologies useful in teaching and learning situations. When using Kahoot! the teacher must be familiar with utilising some basic technologies. For this section, contextual factors such as availability of technologies in schools, teachers' competency in gamification technology, frequency in using gamification technologies, competence in the

integration of ICT and pedagogical insights were reviewed using a questionnaire which was specifically meant to address the research question one.

Availability of technologies in schools

The participants in the semi-structured questionnaire were asked to respond about the availability of information and communication technologies in their schools; two out of nine participants confirmed the availability of a computer laboratory in their school/s. Eight teachers agreed that they were in possession of laptops that were provided by the Department of Education. Eight out of nine teachers agreed to the availability of Internet connectivity in their schools. Lastly, seven out of nine educators confirmed that their schools are in possession of tablets for learners.

Table 9:An extract from the questionnaire (Appendix A, Section B)

Technologies available for teaching and learning	Yes	No
1. A computer laboratory	2	7
2. Computers/laptops for teachers' use	8	1
3. Internet connectivity	8	1
4. Tablets	7	2

The collected data revealed that some schools do not have centralised Internet access provided for the benefit of all learners and teachers in a school. This is confirmed by a statement from one questionnaire respondent, T4 who commented in this section as follows**,** " *In my case, internet access is limited to the laptops given to us by the department of education, and we also access it via our own cellphones".*

Teachers' competency in gamification technology

In this section, participants were required to rate their competency levels of gamification skills by putting an (X) under the headings appropriate to them. For teachers to confidently integrate ICTs in the classroom, they should have competency in ICTs. This is tantamount to the TPACK model by Mishra and Khoehler (2009), who opines that for successful integration of technology into teaching and learning, teachers should have technological knowledge, pedagogical knowledge and content knowledge. The level of competency in gamification technology would determine how the teacher will integrate it into the teaching and learning of the subject matter. From the data presented in **Table 10,** it is evident that the majority of the participants do not have the capability to incorporate gamification technology. One respondent claimed to have fair capability, while the other one claimed to have excellent capability.

Technology	Excellent	Good	Fair capability	Low capability	No capability
	5	4	3	2	1
. Socrative	1 respondent	0	1 respondent	0	7 respondents
. Encarta Games	1 respondent	0	1 respondent	0	7 respondents
. Kahoot!	1 respondent	0	1 respondent	0	7 respondents
. Quizalize	1 respondent	0	1 respondent	0	7 respondents
. Khan Academy	1 respondent	0	1 respondent	0	7 respondents
. Other					

Table 10: Extracted from the questionnaire (Section C: Appendix A)

In the comments section of the questionnaire, participants were required to comment on how they used any of the gamification technologies listed in Table 6, and only two responded. One

commented as follows, "*We are not exposed to any form of technology for teaching and learning**" (T7-Q).*** ***"**I use a computer to operate a gamified lesson and it is always very interesting for learners" **(T4-Q)**.* The picture above meant that the participants needed to be exposed to Kahoot! gamification technology in the form of a workshop before proceeding with the study.

Frequency in using gamification technologies

In this section (**Section C: 2 of Appendix A**), the researcher wanted to understand how often participants integrate gamification technologies in their daily teaching and learning. The scale used was divided into five statements: 1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= All the time, and the participants had to put x in the statements relevant to them. The illustration below shows that the majority of participants had never integrated gamification technologies for teaching and learning, while one participant claimed to be using gamification technologies more often. In the comments section, one participant stated, *"I play engaging quiz games at school, at home and at work" (T4-Q).* T2-Q commented that *"I do not have an idea how to do these in a computer".* Furthermore, T9-Q also commented that "*I wish I could be trained on how to use all these gamification technologies; it is my first time to hear about them".* The comments from the participants were sounded as a call for the orientation of the participants on the gamification technology.

The figure below shows the frequency of use of gamification technology as per the questionnaire responses. All nine participants responded to this section. One teacher indicated the knowledge of four gamification technologies, Encarta games, Kahoot gamification Quizalize and Khan Academy. All other eight participants stated that they had never used any gamification technology.

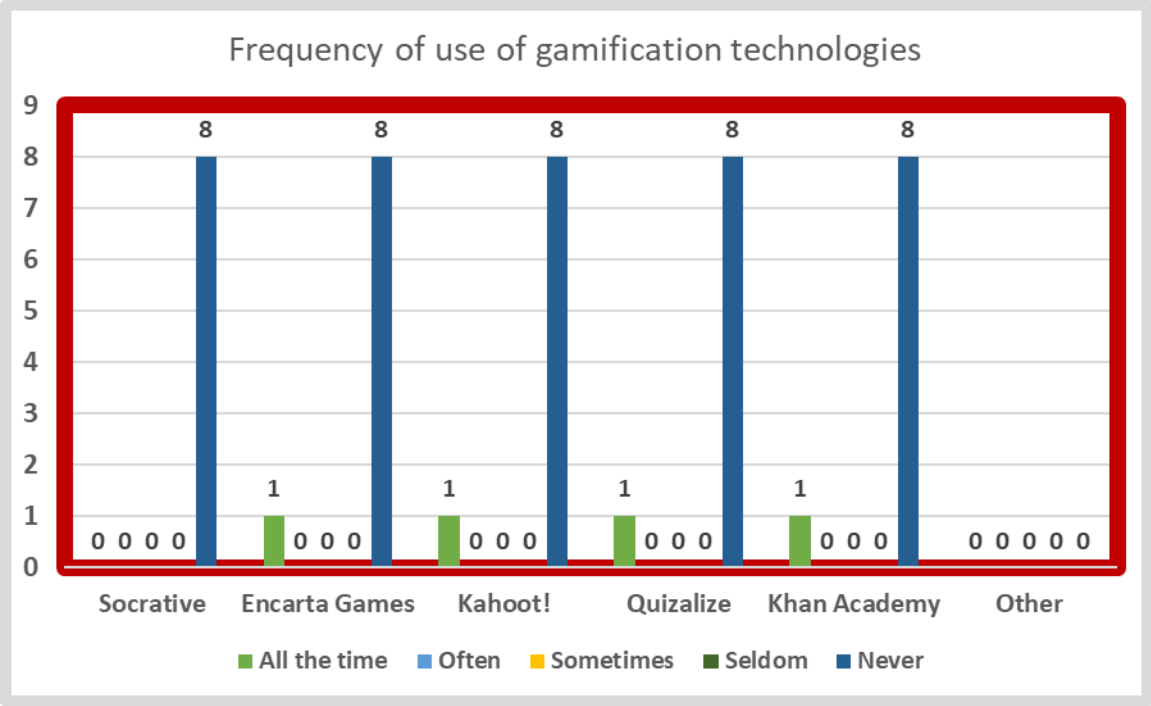


Figure 8: Frequency of using gamification technology

Competency in ICT integration

In this section, the researcher aimed to find out how competent the participants were in integrating ICTs into teaching and learning**.** The participants had to respond to seven questions using a four-point scale questioning technique and were numbered accordingly to capture the responses. 1= Not at all, 2= To a small extent, 3=To a reasonable extent, 4= To a large extent **(see Table 9).** In general, observation of the responses in Table **9** below, most questionnaire respondents are in possession of reasonable ICT integration skills. The majority of respondents agreed with the awareness of ICTs available for teaching and learning, and eight of them agreed with the statement *"I use various ICTs in my teaching"*, though most of them agreed to a lesser extent. Also, on the statements, "*I use ICTs to actively engage learners*" and, "*I have adequate ICT skills to enable me to use technology in my teaching and learning*" the majority of respondents agreed. This implies that the respondents have ICT skills for teaching and learning even though they are not confident enough to incorporate them into their lesson delivery. These responses lay a foundation for the integration of Kahoot gamification technology as they unveil the technological experiences teachers have.

Table 9: Extracted from Appendix A. Competency in ICT Integration

No	ICTs integration	To a large extent	To a reasonable extent			To a small extent			Not at all	
		4	3			2			1	
	Respondents	T1	T2	T3	T4	T5	T6	T7	T8	T9
.	I am aware of ICTs available for teaching and learning	2	3	4	4	1	3	2	2	2
.	I use various ICTs in my teaching	2	2	2	4	1	2	3	2	2
.	I have access to ICTs that I use in my teaching and learning	2	3	3	4	1	2	2	2	3
.	I know how to integrate ICTs in my teaching and learning	2	3	2	4	1	2	3	2	2
.	I use ICTs to actively engage learners	2	2	3	4	1	2	2	2	2
.	I use ICTs to promote learner to learner interaction (e.g., interaction between learners) during the lesson	3	3	2	4	1	2	4	2	3
.	I have adequate ICT skills to enable me to use technology in my teaching and learning	2	3	3	4	1	2	3	2	3

Table 9 shows how each individual teacher responded to each question extracted from the questionnaire (Appendix A) on their ICT integration level of competency. Only one teacher had all his answers in level 4, meaning his or her ICT integration level is on the extreme positive end. Most of the teachers had their responses in level 2, which reflects that their ICT integration competency level is on a small scale.

Teachers' pedagogical insights on gamification technology in teaching and learning

		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
	Gamification technologies are disruptive when teaching	2	0	2	4	1
	Gamification technologies make teaching effective	3	3	2	1	0
	Gamification technologies promote learner to learner interaction	3	2	3	1	0
	Gamification technologies help in improving learner performance	1	3	3	2	0
	Use of Gamification technologies in teaching and learning can improve learners' critical thinking	3	2	3	1	0
	Knowing how to use Gamification technologies by teachers is a good skill	3	3	2	1	0
	Gamification technologies arouse learner curiosity in the learning process	3	3	2	0	1
	Gamification technologies arouse learners' attention and motivate	3	3	3	0	0

	them					
	Use of Gamification technologies in teaching is enjoyable	3	4	2	0	0
	Using Gamification technologies in teaching is difficult	0	5	0	2	2

Table10: Teachers' pedagogical insights on gamification technology in teaching and learning.

This section presents the results of the pedagogical insights of teachers on gamification technology in teaching and learning. Ten questions were set using a five-point Likert scale, Strongly Agree, Agree, Uncertain, Disagree and strongly disagree **(see Table 10).** In general observation, respondents are aware that gamification may assist learner-to-learner interaction. In statement number 1 in **Table 10** below, "*Gamification technologies help in improving learner performance"* three participants responded to being uncertain, two disagreed with the statement and only four agreed on the influence of gamification on learner performance. Six out of nine respondents agreed with the statement, "*gamification technologies arouse learners' attention and motivate them*". In addition, responses in **Table 10** reveal that most participants felt that using gamification technology for teaching and learning is somehow difficult, as five out of nine participants agreed on the statement*, "Using Gamification technologies in teaching is difficult*" but most of them agreed that gamification technologies arouse learner curiosity in the learning process. The responses by participants made the researcher aware of teachers' pedagogical insights on the use of gamification technologies in classrooms.

The summary below shows how the teachers responded to each question based on their pedagogical insights on gamification technology. The researcher observed from the data on **Table 10** , that most teachers believed that technology has a positive impact on teaching and learning as the majority have used Agree or strongly Agree on the Likert scale shown. The statements required teachers to reflect by rating their feelings on questions asking effectiveness of gamification technology, the ability of technology to promote learner-to-learner interaction, technologies and learner curiosity, attention and motivation.

5.4.3. Research Question 2. Use of Kahoot to mediate the learning of probability.

To provide a collective answer to research question two, relevant data from interviews, workshops, journal reflections and lesson observations were collated and analysed. The themes that emerged from the data collected are displayed in **Table 11**.

Table 11: Teachers' experience in using Kahoot to mediate the learning of Probability

Theme	Description
1	Brings fun into the classroom
2	Enhances learner participation
3	Prompt feedback
4	Learner-driven

Kahoot! gamification technology brings fun into the classroom

It emanated from the data sources that the participants unanimously perceived that Kahoot gamification brings fun into the classroom. This is evident from the interview response by T5-1, "*My experience with Kahoot! was that it makes learning more fun. I could see the excitement among learners in the classroom as all of them were using Kahoot! for the first time, but their facial expressions gave me more and more interest*".

Concurringly, T4-I articulated that, "*Leaners get easily bored during our normal teaching and learning but with Kahoot! they enjoy every moment. I prefer to use Kahoot! because it is the easiest way to win learners' interest. I watched them enjoying a mathematics lesson in a way they had never enjoyed before. They do not struggle to calculate; they really enjoy doing it with Kahoot*"

Resonating with other participants, T1-I attested that, "*I found Kahoot! interesting especially when I found that my learners are very interested and their interest is growing more and more as they get deeper into the game*".

In addition, T8-RJ reflected that "*shifting away from the traditional approach and adopting the new teaching strategies makes learning fun and interesting to learners*".

In the general observations by the researcher in all three schools visited, the classrooms were turned into game shows, and the learners were very excited but concentrated on selecting their choice answers into their gadgets. Excitement and joy were visible among learners. They were even dancing to the tunes of Kahoot! games, screaming when they get answers correctly, especially at the end of the game when the list of winners was displayed on the scoreboard. Learners were glued to their gadgets' screens and also to the scoreboards projected by their teachers. Learner interaction was minimal as each learner was using his/her own gadget, and adequate social distance was kept in adherence to Covid-19 protocols. The findings above are supported by Cauthen et al., (2020), who articulate that Kahoot! makes learning fun and interactive, and it involves the practical application of skills as it unleashes the learners' potential to portray their problem solving as well as their critical thinking skills.

Kahoot! gamification enhances learner participation

Learner participation is fundamental in any teaching and learning environment. In a variety of comments from participants, as revealed in the generated data, there were degrees of agreement on the issue of learner participation being enhanced through the use of gamification technology. In the observation guide, it is evident through the field notes taken by the researcher that as the teachers were trained during the workshop, they mastered the content of the training and were taking the lead in their classrooms as the MKOs, assisting and scaffolding their learners to log into the browsers, add the game code and to join the Kahoot! games. Teachers were ensuring that learners reached the ZPD in line with Vygotsky's (1978) SCT, as discussed in Chapter 3 of this study. The data unearthed the willingness of participants to actively participate in learning during the workshop, as reflected in the researcher's personal journal, "*I was heartened to observe that teachers were so willingly participating in the Kahoot training, excited and taking turns to create games, exchanging game pins and retrieving feedback. At first, I was skeptical about their engagement as I saw their ages and teaching experience through the questionnaires and that they would not have the courage to operate Kahoot! lessons"* (PRJ, March 2020*).*

In accord with the reflection above, T1-I stated during the interview, "*I would mention the issue of attention and participation, I usually fight with my learners as I would find them doing other things during my lesson presentation, even when I instruct them to write, time goes by without them having started writing but Kahoot! grabs their attention. There is no struggle for learners to be attentive with Kahoot! instead, they are willing to participate and even assist one another in pursuing the game."*

Another participant aligned with the statement above opined that "*Probability is not a topic that is easy for learners to understand, nor an easy topic of teaching. We use coins and dice to assist with learner understanding, and I never thought that there could be a strategy of teaching it to the extent that learners become willing and actively participate in a probability lesson"* (T3-I).

In contrast to the statements revealed by others, one participant in the reflective journal commented that "*Kahoot! gamification makes learners become uncontrollably excited such that those who finish first disturb those who are still figuring out their answers; a Kahoot! classroom is associated with chaos. The keenness of learners to participate in class is exaggerated" (T6RJ).*

Generally, the findings on learner participation are confirmed by Prieto et al. (2019), who accentuates that Kahoot "improves participation and motivation while increasing the meaningful learning in students, fostering the desire to learn due to the use of languages and technologies with which they are familiarized" (p.2). In the same vein, Licorish et al. (2018) expatiate that "game-based student response systems have been found to foster students' engagement, enhance classroom dynamics and improve overall students' learning experience".

Kahoot! provides prompt feedback

Feedback is significant in the teaching and learning process for its impact on improving learners' performance. It was revealed from the collected data that Kahoot! provides prompt feedback for both learners and teachers. All participants in the workshop commented that "*this technology was able to let each individual know immediately if he or she has answered the*

question correctly or not" (workshop 11 March 2021). One participant was vocal during the workshop after they had been orientated on how to generate the report after the game to say, "*what I like about Kahoot! is that it goes as far as question-by-question analysis instantly, and also tells which learners are struggling with what. Therefore, when we do our remedial activities, we know which learners to target and what areas should we do so that the teacher's intervention will be focused and not a one size fits all*" (workshop 11 March 2021).

All three interviewees commented on the issue of instant feedback; T5-I stated that" *It easy to see difficult questions for my learners, then I am able to go back and teach those areas that seemed to be difficult as per the feedback I got from Kahoot!".* Similarly, another interviewee stated that *"I can see that learning is now learner-centred, and the feedback is very fast in the gamification technology, you can see where most learners have grey areas and you are able to tackle them faster" (T4-I).* T2-I concurred with other interviewees and articulated that, "*One advantage I could highlight about Kahoot! is instant feedback as learners are corrected immediately*." The data in **Figure 7** below shows how the learners get instant feedback on a Kahoot! lesson through their devices. After the learners have entered their game pins, they are prompted to enter nicknames and for easy tracking, it is advisable for them to write their surnames and or names. A screen with answer choices appears with shapes and colours. Learners then click on the colours and shapes that correspond with their choices and quickly get feedback on whether the answer is correct or incorrect and the points accumulated are displayed. Figure 7 is the screen that appears on learners' devices, prompting the learners to choose the answers they think are appropriate for a question displayed on the screen displayed by a teacher. Immediately after choosing the colour keys, they get their feedback.

Figure 1: Kahoot! colour Keys for answering

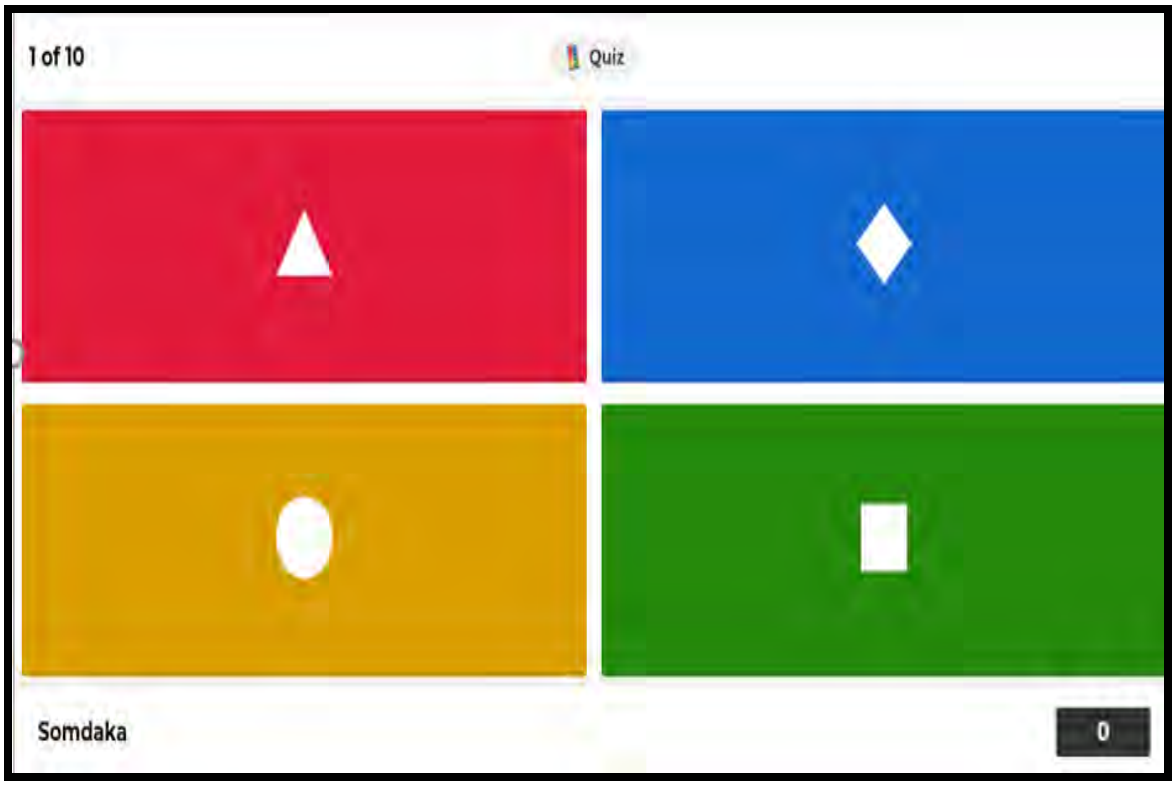
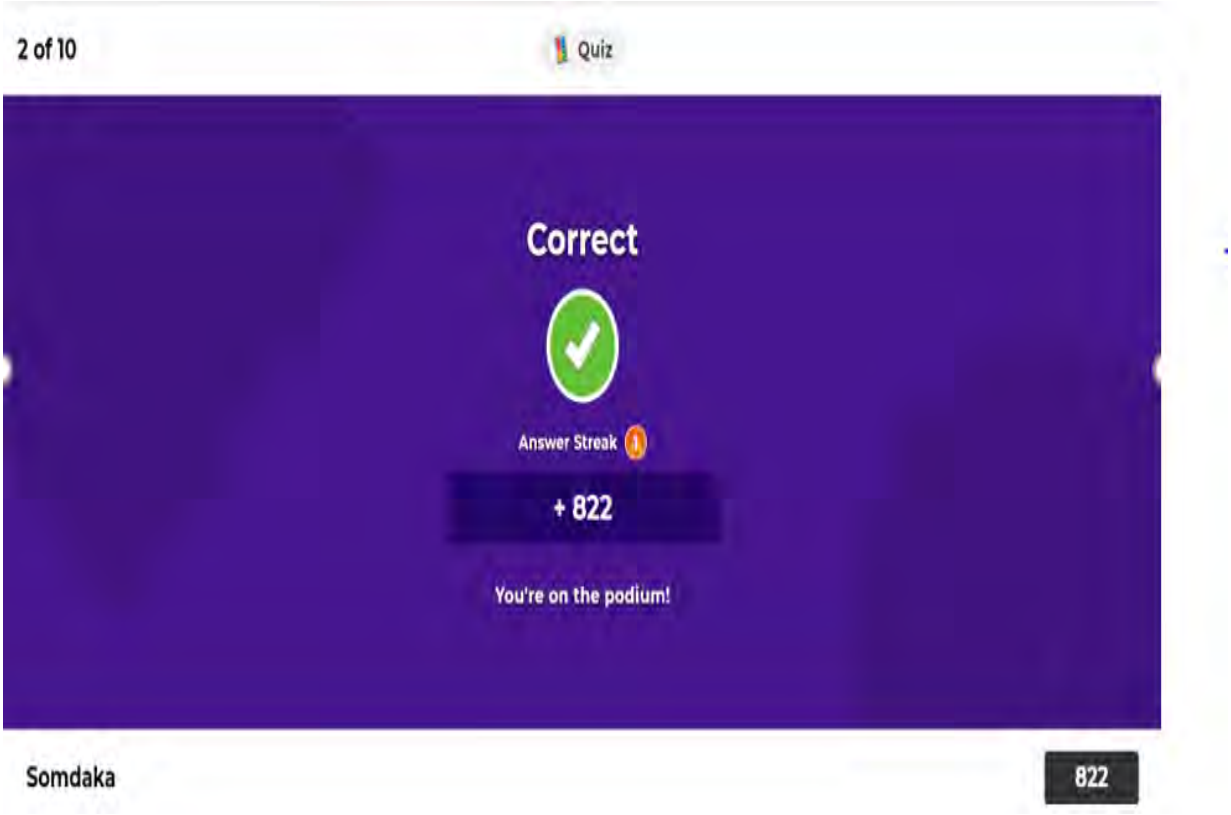


Figure 8 shows the feedback that is given to a learner after making a choice of colour keys for answering the questions. This is also displayed on the learners' screens to show whether the answer given is correct or incorrect, and a score of an individual or a team is provided on that same screen. The number of a question being answered appears on the top left corner of the screen next to the total number of questions that the whole quiz encompasses, thus motivating the learner to work harder and carefully consider the answer choices for the remaining questions. In addition, the name of the learner and the total learners' score are shown at the bottom of the same screen.

Figure 2: Kahoot! Instant feedback on learner devices

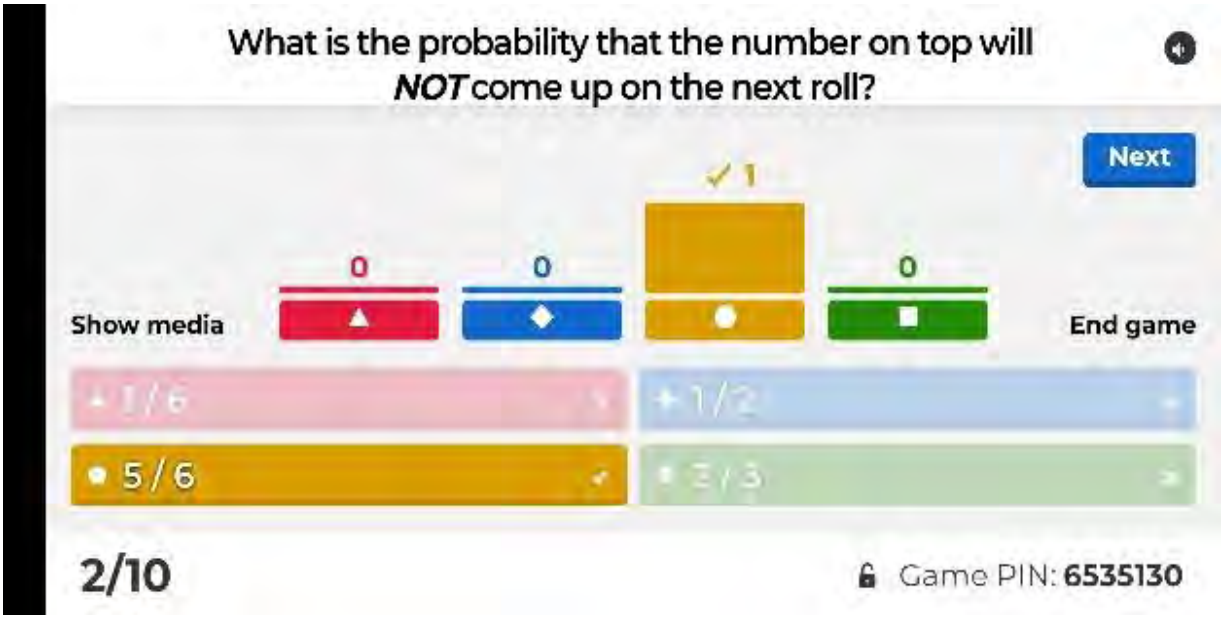


The data in **Figure 8** is confirmed in the observations by the researcher in Kahoot! lessons that were conducted by participants persuading the learners to carefully make their informed choices. Learners were glued to their gadgets in all the schools and would jump with joy when they got correct answers making sounds like "Yes" and lifting up their fists. Some would put their hands on their heads, making comments of sadness like "Aahh" as they were getting instant feedback on their responses.

The data on **Figure 9** below shows the screen that is projected to be viewed by the teacher and learners as they are scoring in the game. The screen below appears after the timer has run out or after everyone has submitted the answers. This is where the teachers were able to see how many learners scored correctly or incorrectly and how many did not even submit the answers. It also shows how many learners chose each of the colour keys. This enables the teacher to detect and rectify the misconceptions of learners. When the teacher clicks the 'next' button, a scoreboard appears with five top scorers and their points in merit order. The display of the

scoreboard is what perpetuated the competitive spirit among the learners from the observed schools. The question is displayed on top of this screen and possible answers that were given are also shown, but most importantly, the correct question with a point awarded to it is displayed. The options to continue with the game or to end it was given. The game code to assist the newly joining learners or those who are disconnected during the game was on display.

Figure 3: Instant feedback visible on the main screen



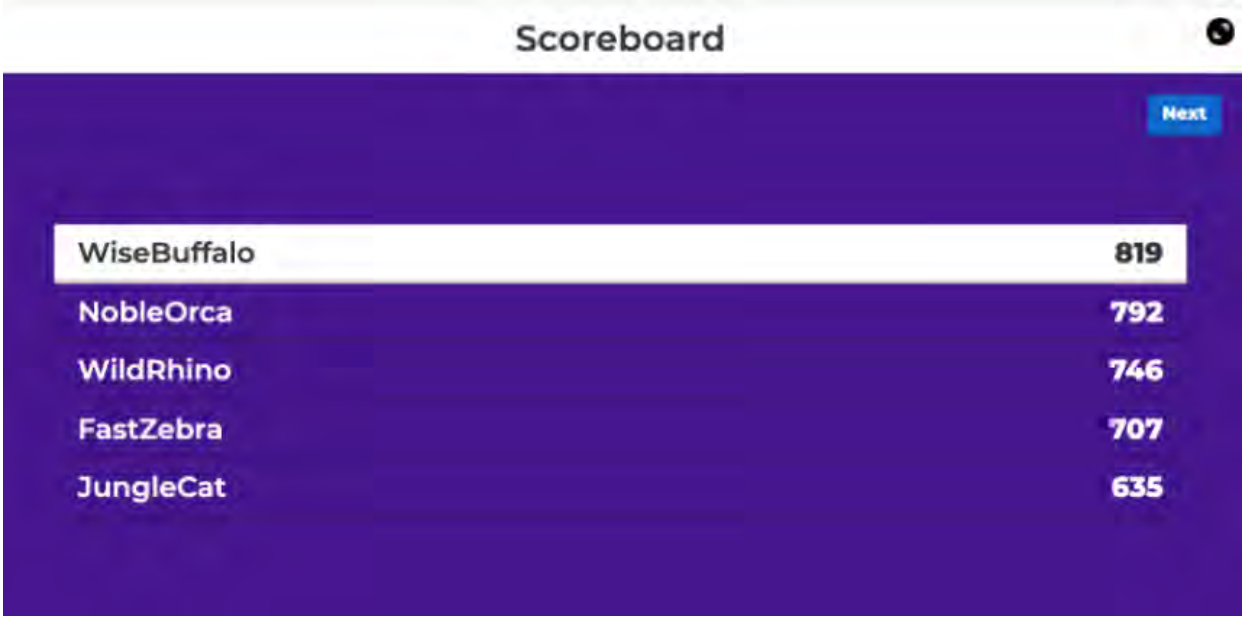


Figure 10: Kahoot! Scoreboard

The scoreboard displays the points as they are scored by an individual or team players in the game. A player with the highest scores is placed on top of the scoreboard, while the player with lower scores is at the bottom. As the scores change during the game, all players are immediately arranged according to their merit.

One participant from Miracle primary school generated an excel report immediately after the lesson to reveal how his learners performed on the game. Each learner could see which areas were difficult for everyone and for each individual learner. This was a best practice for the teacher as it is envisaged that a teacher, after each lesson, should reflect on what went well and what went wrong so as to improve in the next interaction with learners. In addition, in the reflection by T8-RJ, it was stated that "*I think the overall performance of learners would improve as they learn through the games and get instant feedback so that even if the teacher has not yet addressed the grey areas, the capable learners are able to make corrections on their own, also no learner would think is despised by the teacher as the results are automatically generated*".

The findings in this section are confirmed by Ganapathy (2020), as cited in chapter 2 of this study, who attests that Kahoot gives instant feedback on how much the learner knows about the

topic and teachers monitor the progress of their students while they participate in a game through a distribution chart that reveals how all participants are performing in each game. This allows them to rectify grey areas immediately.

One teacher indicated that, "*Quiz is a guesswork. We may think that the learners have mastered the content, only to find they are guessing correctly. A learner can guess and get it right. We might be misled to think that learners understand whereas they don't understand. Learners may also panic due to time limits and choose incorrect answers. There is no chance of scratching and writing the correct answer once the button is touched. No enough time to think due to the pressure of the competition"*. The view of this participant is in line with the findings of Licorish et al. (2018) that "negative aspects of competition came into play when students focused more on the competition and having fun rather than learning" (p.13). For instance, "in their desire to compete, some students rushed to answer questions, not taking the time to understand the questions or the answers" (ibid.p.13).

Kahoot is learner-driven

One of the aspects that were revealed from the gathered data was that Kahoot! gamification technology is learner-driven. The following comments illustrate that the teachers' experienced Kahoot! as being learner-centred.

T5-I commented that, "*Kahoot! compelled me to see the change in the way I present the lesson, because now the interaction is with the learners most of the time, I used to be the one who is teaching, talking, and telling the learners how something is done, now I can see them taking responsibility of their learning, collaborating with each other on how to solve some problems, they even lead me sometimes and they are learning very fast*".

T1-I echoed that, "*I had to adjust my teaching strategy. The game does not allow too much talking from the teacher's side. Also, the set reaction time limits even the chance of explaining the question. I am no longer dispensing information in a Kahoot! class, and my main duty is to operate the system and make it possible for learners to discover concepts as they are moving with the flow of the game. All that is done is on the side of learners and not mine. Learners are learning on their own than to be taught*".

T4-I attested that, "*I realised that my traditional approach to teaching was not enough for teaching Probability. I witnessed my learners willingly tackling questions I thought would be difficult for them on their own with ease. The probability topic was not completed yet, but I saw learners' keenness in answering fractions, halves and percentages, which were never taught in class".*

These findings were also qualified by statements from reflective journals. One participant wrote, "…*I think the best way of teaching Probability with Kahoot! is to flip my classroom and let learners manipulate it before I teach my lesson so that when I explain the concepts to them, they will be in a better position to understand it properly*" (T6RJ).

In contrast with T6RJ, "*The way learners are so hands-on with gamification, I have learnt that the best way to benefit mostly with Kahoot! is for me to introduce the lesson to learners and in order to get their attention I will promise them with a game at the end. After that, I use Kahoot to assess their understanding*" (T2RJ). This coincides with Prieto et al., (2019), who reverberates that Kahoot! comprises a bank of questions that can be launched at the beginning of the lesson to check learners' prior knowledge or at the middle or end of the lesson to check the knowledge acquisition.

The findings above were confirmed in the observations by the researcher. In all schools, learners were taking the lead in their own learning. When they were given the gadgets, they did not even wait for the instructions but switched on the gadgets and connected to the wi-fi access. Teachers only instructed them to go to browsers and type the URLs, and after that, learners could do everything faster until they got into the game itself. Without being asked to assist one another, they were already collaborating, but as the social distance between them was observed, they could not touch one another's devices. At Xolovane Primary, the learners were more excited to play the Kahoot! Games though the teacher seemed to be delaying them. Some of the learners were more technologically advanced and opted to assist the teacher in setting up the laptop and the projector and later play the game.

At Perfect primary, the researcher observed that one learner was so devastated that she cried as other learners were starting to play and the teacher had to stop the game to attend to her. Her

tablet was slow such that she could not submit the first two answers. It turned out that she was the most brilliant child in class but could not tolerate being unable to compete with others. This is commensurate with the findings by Licorish et al. (2018), who mentioned that "negative aspects of competition came into play when students focused more on the competition and having fun rather than learning" (p.13)

5.4.4. Research Question 3: Enabling and constraining factors in the use of Kahoot.

The aim of this section is to respond to research question three of this study, "*How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?".* Three main themes were unearthed by the findings of this study, as tabulated in **Table 12**.

Table 12: Key findings

Theme	Description
1	ICT Infrastructure
2	Teacher competence
3	Conducive learning environment

ICT Infrastructure

It was unveiled through the findings of this study that the availability of ICT infrastructure is one of the factors that determine the incorporation of Kahoot! gamification technology as it may either enable or constrain the teachers' pedagogies. Generally, the research participants in the interviews, workshops, reflective journals, and observations indicated the ICT infrastructure as a phenomenon that is key in integrating technology.

During the workshop discussions, just after teachers were orientated on the gamification technology, the participants raised the issue of the shortage of gadgets for learners and the unstable network reception in their schools. A unanimous agreement was to continue with the study and see what transpires during the process of using Kahoot! for teaching and learning.

One participant commented that *"the issue of connectivity and network coverage poses a serious threat to technology integration, otherwise, when it is working fine, integration is possible" (T-1).*

T5-I indicated that, "There were problems with starting the game due to network challenges prevailing here at school". This supports, Sabandar et al., (2018) as they accentuated that lack or poor internet access is the downside of using Kahoot! in the classroom.

In addition, *T4-1 reflected that "Nothing was challenging in the implementation of Kahoot except for the shortage of gadgets, our school was provided with 24 tablets and my learners are far more than that, and the Covid-19 protocols prohibit us from allowing them to share, as a result for this lesson I had to use only twenty-four learners, leaving out others for another shift".*

During the non-participant observations by the researcher, it was clear that ICT infrastructure impacts technology integration. At Solution Primary school (pseudonym), there was a delay in the starting time of the Kahoot! lesson as the school projector was locked in the principal's office and the principal was not available. It appeared that without the data projector, the Kahoot! class could not be effective. In addition, at Perfect Primary (pseudonym), there were serious mobile network connection glitches on the day of observation with almost all the network providers that were at hand. Learners were so devastated as they were ready to play Kahoot! game. Finally, when we were about to give up, the teacher's laptop connected together with five learner gadgets out of twenty.

The results in this section of the study concur with Pektaş and Kepceoğlu (2019), as cited in Chapter 2, section 2.4. articulating that "as all gamification applications are based on some technology, possible technological problems may affect courses and instruction" (p.70). Also, in chapter 2, ICT infrastructure is defined as the availability of equipment, software, internet

access and other similar resources in the school (Pelgrum 2001). Furthermore, Mosesa et al., (2012) opined that lack of ICT infrastructure could be one of the factors that constrain the integration of technology in mathematics. The evidence from participants' comments above suggests that educators have fewer prospects to utilize instructional technology when the ICT infrastructure is not well provided for.

Teacher Technology Competence

Evidence from the data collected suggests that teaching with Kahoot! gamification technology relies on teacher competence. Teachers' competence is one of the enabling or constraining factors in the utilization of Kahoot! gamification, if teachers are competent, it is likely that they will integrate Kahoot! into the delivery of curriculum, whereas if teachers are not competent, the chances of integrating technology in their teaching are slim. Comments from participants suggesting the training of teachers for improved competence were as follows:

"*Teachers need to be trained on the utilisation of Kahoot in-order for them to integrate it into the curriculum"* (T4-I).

"In my school, I think the age of teachers and their resistance to change is hampering the use of technology, teachers are attached to the chalk and talk. The only solution is to train and scaffold them to use Kahoot especially those who teach mathematics" (T5-I).

"I have gained a lot out of the workshop because I was not familiar with using technology for teaching, I did not know that it is easy to learn. If I can do it, it means a teacher who is trained on Kahoot! would be able to use it to assist learners and make learning fun. I am looking forward to using Kahoot in all my subjects as well" (T6-RJ).

"I am thrilled at the progress made by the participants in the workshop. Before we started, they were not familiar with Kahoot gamification, but after they were orientated, they were willing to demonstrate what they had mastered. I was fascinated by their confidence" (PRJ March,2021).

One participant attested that, "*The majority of teachers are scared to use technology and most of them were given laptops which they do not use. … Anyone who can use a phone can be able to use Kahoot! It is just a matter of knowing how to get into Kahoot! It does not require much technological knowledge. Anyone can do it. There is no special expertise required"* (T1-I*)*.

The findings above are in line with the findings by Voogt et al., (2010) surfaced the reasons attributed by mathematics teachers for not integrating ICT in their instruction and "among others, lack of ICT knowledge in integration: lack of knowledge about ways to integrate ICT in the lesson and lack of training opportunities for ICT integration knowledge acquisition" (p.436).

Conducive environment

It emanated from the generated data that a conducive environment may enable or constrain the utilization of Kahoot gamification technology. The conducive environment in this study referred mainly to the physical space.

T8RJ pointed out that *"Physical space is limited, unavailability of internet connection or low coverage, unavailability of data. These could be addressed when our school's infrastructure is improved …. the buildings and the computer laboratory should be made available"*

T5-I added that, *"The classroom space is not enough and not suitable for computing, not enough sockets to connect to electricity …".*

"In my classroom setting, I do not have a projection space; this is a challenge because if I want a space for ICT integration. I have to go to find a conducive space if I plan to use technology, especially during this Covid era where social distancing between learners is much needed than ever" (T3-I).

In supporting the above notion of the conducive environment, Lynch (2021) stipulates the importance of creating conducive classroom environments for the integration of technology and that the focus on the physical space should not be overlooked. The comments above suggest that the environment plays a major role in the smooth integration of technology. If the

environment is conducive, especially in terms of the physical space there is a likelihood that ICTs could be integrated in the lesson delivery. The lack of a conducive environment for ICT implementation leads to minimum or non-utilization of ICTs in the classroom setting.

5.6.1. Conclusion

In this chapter, findings generated from nine research participants were presented as guided by the three research questions posed at the beginning of this study based on: technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a gamification technology in facilitating Probability mathematics learning in rural schools. Utilization of Kahoot! to mediate learning of Probability in mathematics subject in rural schools. Enabling and constraining Factors on the incorporation of Kahoot!! gamification in Probability lessons.

As pointed out in the previous Chapter, the semi-structured questionnaires, semi-structured interviews, non-participatory observations, journal reflections as well as workshop discussions were the instruments used to generate data that was analysed in this chapter. The main findings in this study unveil that Kahoot! is learner-driven, provides prompt feedback and makes learning fun. Furthermore, ICT infrastructure, teacher competence and a conducive environment were found to be the enablers or constraining factors on the utilisation of Kahoot gamification! The next chapter presents a discussion of this study's findings.

Chapter 6

Discussion of findings

6.1. Introduction

The previous chapter outlined the findings of this research study as per data collected from the participants through the research instruments as part of the methodological procedures for the study. This chapter presents the discussion of findings pertaining to the three research questions that had to be answered to address this study's overarching question. Each question is discussed separately, drawing on the literature as presented in chapter two and the theoretical framework discussed in chapter three to support the explanation of the data provided by the participants. The presentation of this chapter is structured in sections according to (6.1) introduction, (6.2) discussion of key findings, and finally, (6.3) conclusion.

6.2. Discussion of Key findings

The overarching question for this study was: How do grade six teachers make use of Kahoot! gamification technology to facilitate the learning of Probability in their classrooms? In answering this question, the three sub-research questions were posed:

- What are the technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a Gamification technology in facilitating Probability mathematics learning in rural schools?
- How do Grade 6 teachers make use of Kahoot! to mediate learning of Probability in mathematics subject in rural schools?
- How does the incorporation of Kahoot! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?

These research questions guide the discussion of the findings in this study.

6.2.1. Technological experiences and pedagogical insights on the use of Kahoot!

The findings in this section were obtained through the use of a questionnaire that was designed to explore the basic technological experiences and pedagogical insights that grade 6 teachers already have on the use Kahoot! gamification technology in facilitating probability. In examining the technologies available in schools, the data revealed that most of the teachers in the Amathole East District possess basic technologies. On the question, "*Are the following facilities available at the school you are teaching?" The participants were required to put an X at the field appropriate to them.*

Technologies available for teaching and learning	Yes	No
. A computer laboratory	2	7
. Computers/laptops for teachers' use	8	1
. Internet connectivity	8	1
. Tablets	7	2

Table 13: An extract from the questionnaire (Appendix A, Section B)

Eight participants were in possession of the departmental laptops that were loaded with data bundles to access the Internet, while the other two confirmed the availability of computer laboratories in their schools. Also, eight out of nine educators confirmed that they were in possession of departmental laptops with internet connectivity. Seven participants also nodded to the availability of learner tablets in their schools. In addition, seven out of nine participants indicated that they have tablets available for use in the classroom by learners. The above findings assure that the participants had access to technologies that would enable them to integrate Kahoot! gamification into the teaching and learning of probability. This is consistent with YÜRÜK (2019), who articulates that teachers need computers projected on a screen and

get into the web address to launch Kahoot! while learners can use computers, smartphones, laptops and tablets to get into the Kahoot! games.

Also, the findings of this study reveal that many research participants of this study did not have the capability to incorporate gamification technology into the teaching of the topic of Probability. One respondent claimed to have fair capability, while the other one claimed to have excellent capability. Teachers' level of competency in gamification technology is key in determining how the teacher would integrate Kahoot! into the teaching and learning of the subject matter. In addition, this study discovered that the majority of participants had never used gamification technologies for teaching and learning, and only one participant claimed to be frequently using gamification technologies. Furthermore, the findings of this study showed that most of the participants were competent in ICT integration but were not confident enough to incorporate them into their lesson delivery. These responses lay a foundation for the integration of Kahoot! gamification technology as they unveil the technological experiences teachers have. These results are commensurate with the TPACK Framework on which this study is grounded, as discussed in Chapter three. The TK of teachers is important in the integration of technology, and since this study is premised on the use of Kahoot as a gamification technology in teaching, it is necessary to have knowledge of various technologies useful in teaching and learning situations (Schmidt al., 2014). Also, Wang (2009) refers to TK as the teachers' competencies in utilising the ICT Tools. As participants were using Kahoot! they should at least be familiar with connecting the projector to a laptop or any computer, surfing the internet using search browsers, and using tablets and or computers. Technological knowledge is necessary even though Kahoot does not need high computational skills to integrate and use in teaching and learning.

Moreover, the findings of this study reveal that the participants had positive pedagogical insights on gamification technology in teaching and learning. The majority of the respondents agree that gamification technology helps to improve learner performance and arouses learner attention, curiosity and motivation. On the other hand, most of the participants felt that using gamification technology for teaching and learning is somehow difficult as the majority agreed with the statement, *''Using Gamification technologies in teaching is difficult*". The findings for research question one resonate with the literature reviewed in Chapter 2 of this study. For

example, Buabeng-Andoh (2012) identified poor ICT skills, low teacher confidence, insufficient pedagogical teacher training, absence of suitable educational software, limited access to ICT, the inflexible structure of traditional education systems as well as limiting curricula and lesson design as some of the reasons that inhibited the use of technology by teachers. In addition, the findings by Voogt et al., (2010) surfaced the reasons attributed by mathematics teachers for not integrating ICT in their instruction and "among others, lack of ICT knowledge in integration: lack of knowledge about ways to integrate ICT in a. lesson and lack of training opportunities for ICT integration knowledge acquisition" (p.436). Initially, the participants of this study, as per the findings had limited knowledge of the incorporation of gamification technology into their classrooms.

6.2.2. Use of Kahoot! to mediate the learning of probability.

Based on the data gathered through the workshop, journal reflections, observations and interviews, the findings for this section revealed both positive and negative perceptions from the participants.

The findings of this study surface that teachers perceive Kahoot gamification technology as bringing fun into the classroom. This observation is consistent with Cauthen et al., (2020), who articulate that Kahoot makes learning fun and interactive. It involves the practical application of skills as it unleashes the learners' potential to portray their problem-solving and critical thinking skills. Similarly, Yuruk (2019) confirmed in the findings of his study that kahoot! increases student excitement and creates a fun, enjoyable environment. This is also supported by Setiawan and Soeharto (2020), who propounded in the findings of their study the interest shown by students in learning mathematics with Kahoot. They further postulated that the students had an overwhelming motivation and interest to win the game and Kahoot! triggers students to compete with their friends so that "*it grows on students' desire to succeed and becoming champions" (46).*

In addition, another general finding, as evident in the collected data and as cited by the majority of teachers, is that Kahoot! gamification enhances learner participation in Probability mathematics lessons. This concurs with the findings by Licorish et al. (2018), which testified

that the use of Kahoot! in class fosters students' engagement, enhances classroom dynamics and improves overall students' learning experience. Also, Prieto et al. (2019) accentuate that Kahoot improves participation and motivation and increases the students' desire to learn. Likewise, Barus and Soedewo's (2014) findings unearthed that learning with Kahoot creates an environment where learners can actively participate.

Another finding of this study was that Kahoot! provides prompt feedback for both teachers and learners. This finding is crucial as it relates to the improvement of learner performance, especially for the learning of mathematics. This is supported by Nah et al., (2014), as cited in Chapter 2 of this study, who opines that frequent, intensive and immediate feedback is crucial for learning effectiveness and learner engagement. Likewise, Dicheva et al., (2015) agreed that shortened feedback cycles provided by Kahoot are more effective in education as they offer immediate rewards instead of long-term benefits which may be vague. Also concurring with this finding, Ganapathy (2020) attested in his findings that Kahoot gives instant feedback on how much the learner knows about the topic and teachers monitor the progress of their students while they participate in a game through a distribution chart that reveals how all participants are performing in each game. Immediate feedback enables the immediate rectification of misconceptions and grey areas. This allows them to rectify grey areas immediately.

Another finding that emerged from most of the participants was that Kahoot is learner-driven. The participants cited the shift from their traditional methods of teaching and that the learners took the lead. The participants claimed that with Kahoot! they stopped being dispensers of information.

Another finding was that Kahoot! may lead to an unhealthy competition as some learners may be devastated by some of the proceedings of the game as it was cited in the previous chapter (See Chapter5) that one learner was so devastated that she cried as she could not start together with other learners to play. This is consistent with the findings by Licorish et al. (2018), who mentioned that "negative aspects of competition came into play when students focused more on the competition and having fun rather than learning" (p.13).

6.2.3. Enabling and constraining factors of using Kahoot! Gamification technology.

The discussion in this section responds to research question three of this study, "*How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?"*. Three main themes: ICT Infrastructure, teacher competence and conducive learner environment emerged as factors that could enable or constrain the incorporation of Kahoot! gamification technology for mathematics teachers' pedagogies.

It transpired from the findings of this study that the availability of ICT infrastructure is one of the factors that determine the incorporation of Kahoot! gamification technology as it may either enable or constrain the teachers' pedagogies. This finding confirms the results shared by Pektaş & Kepceoğlu (2019), as cited in Chapter 2, section 2.4. explicating that all gamification applications rely on technology and, therefore, any possible technological problems may affect teaching and learning. ICT infrastructure, as defined in Chapter 2, refers to the availability of equipment, software, internet access and other similar resources in the school (Pelgrum 2001). Mosesa et al., (2012) opined that the lack of ICT infrastructure could be one of the factors that constrain the integration of technology in mathematics. In the same vein, Sabandar et al., (2018) reverberate that lack or poor Internet access is the downside of using Kahoot! in the classroom.

Evidence from the data collected suggests that teaching with Kahoot! gamification technology relies on teacher competence. If teachers are competent, it is likely that they will integrate Kahoot! into the delivery of curriculum, whereas if not competent, the chances to integrate technology in their teaching are minimal. The findings above resonate with the findings by Voogt et al., (2010) that surfaced the reasons attributed by mathematics teachers for not integrating ICT in their instruction and "among others, lack of ICT knowledge in integration: lack of knowledge about ways to integrate ICT in a lesson and lack of training opportunities for ICT integration knowledge acquisition" (p.436).

It emanated from the generated data that the conducive environment may enable or constrain the utilization of Kahoot gamification technology. The conducive environment in this study referred mainly to the physical space. In supporting the above notion of the conducive environment, Lynch (2021) stipulates the importance of creating conducive classroom

environments for the integration of technology and that the focus on the physical space should not be overlooked.

6.3. Conclusion

The intention of this chapter was to present findings pertaining to how Grade six teachers make use of Kahoot! gamification technology to facilitate the learning of probability in their mathematics classrooms. The results were drawn from the generated qualitative data discussed in line with the theoretical framework and the literature review of this study. In addition, the findings from Chapter five were discussed on the basis of the research questions posed at the beginning of this study. Also, the discussion shows that these findings align with several studies that are reviewed and discussed above. The findings revealed that the participants had a positive attitude and supported the utilization of Kahoot! gamification technology in the facilitation of probability in their classrooms. The next and final chapter presents the study's conclusions and recommendations of the study and also provides suggestions for further studies.

Chapter Seven

Conclusion and Recommendations

7.1 Introduction

The previous chapter provided discussions of the findings of this qualitative case study. The themes and categories that emerged from the data were carefully identified and discussed. This study's research goals have been chapter presents the overview of the whole study and the aim is also to establish whether the study's research goals have been accomplished. In addition, this chapter presents conclusions and recommendations. The discussion in this chapter begins with the overview of the study, the summary of the study chapters, a summary of the key findings, and the limitations of the study. Recommendations and suggestions for further research are well articulated.

7.2 Overview of the study

The main aim of this study was to explore how Grade 6 teachers make use of Kahoot! gamification to facilitate learning of Probability in their classrooms in the Amathole East District rural primary schools. The following sub-research questions were posed in an attempt to achieve this goal.

- What are the technological experiences and pedagogical insights of Grade 6 teachers on the use of Kahoot! as a Gamification technology in facilitating Probability mathematics learning in rural schools?
- How do Grade 6 teachers make use of Kahoot! to mediate learning of Probability in mathematics subject in rural schools?
- How does the incorporation of Kahoot!! Gamification in Probability lessons enable or constrain mathematics teachers' pedagogies?

This qualitative case study was underpinned by the interpretive paradigm in-order to study the participants in their real-life settings and their schools and to effectively address the research problem. This choice was discussed and justified in depth in Chapter 3. Nine mathematics teachers from four schools in the Amathole East district were selected by employing a purposive sampling method. Data was collected using semi-structured questionnaires, semi-structured interviews, observations, workshop discussions and reflective journals. The TPACK by Mishra & Koehler (2009) and Vygotsky's (1978) socio-cultural theories were employed as the lenses through which all the proceedings of the study were based.

7.3. Summary of the study chapters

Chapter One presented the context and background of this study. The problem statement, the overarching research question, and the purpose and significance of this study were clearly articulated and explained in this chapter.

Chapter Two provided a relevant literature review related to the study. It explored the existing knowledge about the overarching topic and situated this study within the context of existing literature. Literature had been thematically represented according to the goals of the research and the researcher also took cognizance of the research questions as detailed in chapter one during the review process. The reviewed literature focused on probability in mathematics teaching and learning, the role of technology in teaching mathematics in South Africa, the incorporation of gamification in basic education, the use of Kahoot! as a gamification technology in teaching and learning, and lastly, using Kahoot! gamification in mathematics teaching. The literature reviewed shows that although significant research has been done on the use of Kahoot for teaching various subjects and topics, very little was done on the integration of Kahoot! In teaching the topic of Probability at the primary level in a rural context. Also, the literature reviewed revealed that the integration of Kahoot enhanced the teaching and learning of mathematics.

Chapter Three provided a detailed description of the theoretical and analytical frameworks that underpinned this study. This study was broadly grounded by Socio-Cultural Theory (SCT) as a theoretical framework and Technological Pedagogical and Content Knowledge (TPACK) theory as an analytical framework. The appropriate questions for the study were developed based on this

framework. It also guided the researcher in choosing the research design, data gathering techniques, and the interpretation of outcomes. Furthermore, this chapter justified the choice of the TPACK model over TAM and SAMR, which were also models worth to be chosen. The limitations of the TPACK model used as the analytical framework of this study were discussed.

Chapter Four gave a full description of the methodology employed to achieve this study's goals. The paradigm, design, approach and methods used for this study were discussed and the motive behind their choice was justified in detail. An account of the selection of participants and the positionality of the researcher was provided. Data generation techniques, semi-structured questionnaires, semi-structured interviews, journal reflections and non-participant observations were thoroughly analysed. The methods used to analyse the data were also discussed in depth. In addition, this chapter discussed triangulation, trustworthiness, credibility, transferability, and confirmability of the study. The chapter concluded by reviewing the ethical considerations of this study.

Chapter Five of the study presented the results from the data generated through semi-structured questionnaires, semi-structured interviews, non-participatory observations, and journal reflections. The findings were clearly detailed and consistent with the study's methodology. The results presented the participants' perceptions, understanding, interpretations and experiences. This chapter appropriately represented the respondents' responses in their own words.

Chapter Six focused on the discussion of the findings of the research. The findings were compared and contrasted with the previous studies through literature reviewed as per Chapter two of this study. This chapter expansively answered the three research questions posed at the beginning of this study.

Chapter Seven is the concluding chapter of this thesis. The chapter provided an overview of the whole study. It also presented the main conclusions based on findings and the implications of the study. Key recommendations were proposed. In addition, areas for future studies have been recommended.

7.4 Summary of main research findings.

The major findings were discussed in relation to the research questions and themes that emerged from the results of the study.

7.4.1. Technological experiences and pedagogical insights on the use of Kahoot!

The findings of this study revealed that access to ICT infrastructure is still a challenge in most primary schools in the rural areas of Amathole East District. In examining technologies available in schools, the data revealed that most of the teachers in Amathole East District in the Eastern Cape possess basic technologies, which are their individual laptops supplied to them by the Department of education. It also emerged that primary schools that have ICT laboratories are few. Also, schools rely mostly on the data bundles loaded on the teachers' laptops by the Department of Education for Internet access. In addition, seven participants confirmed the availability of learner tablets in their schools which were donated by well-wishers. This confirms that the roll-out of ICTs to primary schools is still in its infancy stage. From the findings, it appeared that the majority of teachers lacked technological knowledge in integrating gamification technology in the teaching of probability. As the participants of the study were experienced in-service teachers, they had sound content and pedagogical knowledge (PCK). TK was, therefore, key in determining how well they would integrate Kahoot! into the teaching and learning of the subject matter. Teachers unveiled their low level of TK in the utilization of gamification technology, and TK was necessary for the utilization of Kahoot even though Kahoot! does not require any high computational skills. This research study, therefore, tried to vector the teachers' TK through the workshop held to train them for the utilization of Kahoot! to mediate the learning of Probability. The teachers, therefore, acquired a different teaching approach for the topic of Probability through their active participation and collaboration during the workshop.

Moreover, the findings of this study reveal that teachers had positive pedagogical insights on gamification technology in teaching and learning. It emerged from their opinions, as detailed in Chapters 5 and 6 of the study, that they believe that the incorporation of gamification technology in the teaching of probability topic of mathematics would increase learner participation and could benefit the improvement of learner performance.

7.4.2. Use of Kahoot! to mediate the learning of probability

It emerged from the data gathered for this study that teachers perceived Kahoot gamification technology as bringing fun into the classroom as learners become overwhelmed with intentions to play and win. The findings also reveal that Kahoot! gamification enhances learner participation in the lessons of Probability. A number of teachers agreed that Kahoot! provides prompt feedback for both teachers and learners, which assists in monitoring learner progress and enables immediate rectification of misconceptions in probability lessons. Another finding that emerged from the majority of the participants was that Kahoot is learner-driven and the participants cited that there was a shift from their traditional methods of teaching and the learners took the lead.

Also, negative aspects of Kahoot were revealed and the participants cited that Kahoot! has the potential to lead to unhealthy competition and some learners may be devastated by the proceedings of the game and become anxious such that their performance could be unsatisfactory. Also, the issue of challenging classroom control was mentioned by one of the participants.

7.4.3. Enabling and constraining factors of using Kahoot! Gamification technology.

The key findings in this section suggest that the enabling factors could also be possible constraining factors in the use of Kahoot! gamification. Three factors: ICT infrastructure, teacher competence, and conducive learner environment emerged as factors that could enable or constrain the incorporation of Kahoot! gamification technology for mathematics teachers' pedagogies.

The availability of ICT infrastructure determines the incorporation of Kahoot! gamification technology, whereas the lack of ICT Infrastructure restraints the teachers' pedagogies. This finding has been confirmed through the observations in schools where the mobile and Internet network reception was of good quality, the Kahoot! lessons on probability went on smoothly, and in places where there was poor connectivity Kahoot! integration was constrained. In addition, due to adherence to COVID-19 protocols, sharing gadgets was not possible. Therefore, integrating ICT may be time-consuming as the learners had to wait until the first groups were done before they could also start the game.

Findings from the data collected suggest that teachers' competence is key in the integration of Kahoot! gamification technology. When teachers are competent, the likelihood is that they will integrate Kahoot! into the delivery of curriculum, whereas if not competent, there will be little or no integration at all. Similarly, the data from this study suggests that the school environment was another factor that was unveiled from the data that may enable or constrain the utilization of Kahoot gamification technology. In schools where physical space is conducive, integration is possible, unlike in schools with a less conducive environment.

7.5. Limitations of the study

This section seeks to acknowledge the limitations that this study was subjected to. Two nearby schools refused to be part of the research for fear of being overburdened with work and the thought that the research would have bad reflections about their schools. This posed a challenge as the researcher had to travel long distances to access the participants that were willing to participate in the study.

The data was gathered during the Covid-19 pandemic, and this period remarked an era when the department of education had prohibited visits to schools, the researcher had to wait until the prohibition was lifted to continue with data collection.

Also, the COVID pandemic posed a challenge because learners could not be observed all at once due to social distancing and no grouping or sharing of devices was allowed, Kahoot! games require learners to login using their devices apart from those used by a teacher. The participants had to allow learners to take turns to have access to Kahoot! games.

7.6. Conclusion

Educators grapple with finding appropriate methods to teach probability, and learners tend to get bored with the traditional approaches to teaching and learning. This study explored working with Grade 6 Mathematics teachers on the use of Kahoot! gamification technology to mediate learning of probability. In this interpretive study, a qualitative case study approach was employed. The data

was generated through the triangulation of semi-structured questionnaires, semi-structured interviews, non-participatory classroom observation schedules, journal reflections, and field notes. The study was conducted with nine participants from four schools. The findings of the study portrayed that the use of Kahoot enhances the learning of probability in rural primary schools.

7.7. Recommendations

7.7.1. Extensive Continuous teacher TPACK development.

The fact that Eastern Cape teachers are in possession of laptops does not necessarily mean that they integrate ICT into their teaching and learning process. This initiative should be complimented by the provision of other technologies that could support teachers to integrate into teaching and learning. Teachers should be trained and supported extensively to acquire relevant technological knowledge on the use of ICTs in curriculum delivery in classrooms and strengthen the use of ICTs in curriculum delivery in classrooms.

Teachers should be encouraged to effectively and maximally utilize the technological devices that are available at their disposal. Technology is developing and changing daily, therefore, teachers need to consistently keep themselves abreast of emerging technologies. Teachers' TPACK development should be encouraged as it has the potential to offer knowledge and skills for selecting technologies appropriate to pedagogy and specific content. They should be able to relate technology with the relevant learning outcome and acknowledge that technology is not a one-size-fits-all, some pedagogies may not be appropriate for specific technologies, and some content may not be suitable for certain technologies.

7.7.2. Improved ICT Infrastructural provisioning

ICT infrastructure is one of the constraining factors in the integration of technology, as identified in the study. The rollout of technologies to rural primary schools should be prioritized as primary education serves as a build-up to high school education, especially for subjects that are accumulative as mathematics. A needs analysis should be done to check the most common needs amongst the school so that the most appropriate technologies should be supplied. Gamification is more compatible with mobile technologies and a plan for the provision of such technologies in

rural primary schools should be put in place. The establishment of external partners for this cause is highly recommended. The Department of Education should ensure that all schools have equitable access to WI-FI and other ICT resources and that the number of technology devices provided per school be increased to meet ICT integration requirements which may lead to improved performance in schools.

7.7.3. Incorporation of gamification technology in the curriculum

The Department of Education in South Africa and curriculum designers should need to exercise flexibility to create a space for the consider integration of gamification technologies such as Kahoot! in the curriculum. Gamification makes learning more engaging and interesting for learners and it shifts away from the boring traditional methods. It creates an internal quest amongst learners to conquer and succeed, thus making the classroom versatile. It is also a means to curb the prevailing high drop-out rate by ensuring learner satisfaction in the education system. Advocacy needs to be done for teachers and School Management Teams to make them aware of the benefits of gamification technologies such as Kahoot! in the teaching and learning practice.

7.8 Recommendations for further studies

- Gamification is an emerging teaching approach that is growing gradually with a lot of potential in the field of education. This study explored only the use of Kahoot! gamification technology in teaching. This opens the opportunity for further research to explore the effectiveness of other gamification technologies in education.
- In addition, this research was designed to explore only the use of Kahoot gamification in teaching, from the perspective of teachers and did not investigate the learners' perceptions and experiences in using Kahoot! gamification technology for learning. Therefore, further research should be conducted to explore the learners' perspective on using Kahoot! gamification technology in the learning of Probability lessons.
- This thesis was orchestrated as a qualitative interpretive study with a small sample of nine participants. Therefore, it is recommended that future research be conducted empirically, using a mixed-method approach to a relatively larger sample, to investigate and analyse the learner achievement in relation to the integration of Kahoot! in the curriculum.

- In conclusion, the researcher acknowledges that according to the CAPS document for Grade six, Probability topic is supposed to be taught through traditional games, using coins and dice. Further research should be conducted to investigate the effectiveness of using indigenous games in the teaching and learning of Probability topic.

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Appendix A : Questionnaire

Semi-structured questionnaire

Date: _____

Introduction

This is an M Ed research questionnaire designed to obtain your views based on your technological experiences and Pedagogical insights on the use of Kahoot! as a Gamification Technology in teaching. Kindly be open and as 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 and 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. For each question you read, there are indications on the number of possible choices. Tick in the appropriate box(es) 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: Personal profile

Age	
Gender	
Highest qualification	
Years of teaching experience	
Current grade(s) taught	
Subjects taught	

Section B: Available Information and Communication Technologies (ICTs) Infrastructure at School

For the purposes of this study, ICTs refers to technology used in teaching and learning, such as tablets, computers, the internet and data projectors.

1. Are the following facilities available at the school you are teaching?

Respond by putting an (X) under the appropriate heading.

Available for teaching and learning	Yes [1]	No [2]
A computer laboratory		
Computers/laptops for teachers' use		
Internet connectivity		
Tablets		

Comments

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Section C: Teacher Competence on Integration of Gamification into Teaching at School

1. Information and communication technologies (ICTs) competency

Rate your level of Gamification skills by putting an (X) under the appropriate heading.

	Excellent	Good	Fair capability	Low capability	No capability
	5	4	3	2	1
Socrative					
Encarta Games					
Kahoot!					
Quizalize					
Khan Academy					
Other					

Comment on how do you use any of the above Gamification Technologies

……

……

……

2. How often do you use the following Gamification technologies in your teaching? Put an (X) under the appropriate heading.

Computer applications	All the time	Often	Sometimes	Seldom	Never
	5	4	3	2	1
. Socrative					

. Encarta Games					
. Kahoot!					
. Quizalize					
. Khan Academy					

Comment on any issues raised above

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3. To what extent do you incorporate information and communication technologies (ICTs) when teaching?

Indicate your response with an (X) appropriately.

No	ICTs integration	To a large extent	To a reasonable extent	To a small extent	Not at all
		4	3	2	1
.	I am aware of ICTs available for teaching and learning				
.	I use various ICTs in my teaching				

0.	I have access to ICTs that I use in my teaching and learning				
1.	I know how to integrate ICTs in my teaching and learning				
2.	I use ICTs to actively engage learners				
3.	I use ICTs to promote learner to learner interaction (e.g., interaction between learners) during the lesson				
4.	I have adequate ICT skills to enable me to use technology in my teaching and learning				

Comment on any issues raised above

……

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SECTION D: Teachers' Pedagogical Insights on Gamification Technology in Teaching and Learning

Please respond by putting an (X) to indicate your level of agreement from strongly agree to strongly disagree.

		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
		5	4	3	2	1
.	Gamification technologies are disruptive when teaching					
.	Gamification technologies make teaching effective					
.	Gamification technologies promote learner to learner interaction					
.	Gamification technologies help in improving learner performance					
.	Use of Gamification technologies in teaching and learning can improve learners' critical thinking					
.	Knowing how to use Gamification technologies by teachers is a good skill					
.	Gamification technologies arouse learner curiosity in the learning process					
	Gamification technologies arouse learners' attention and motivate them					
	Use of Gamification technologies in teaching is					

	enjoyable					
.	Using Gamification technologies in teaching is difficult					

Comment on your experience of using Gamification Technologies in teaching.

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Appendix B : Journal Reflection

Journal Reflection on daily activities *Date:*

Instruction: Answer all the following questions

Instruction: Please reflect on the following points

1. Briefly explain in what way do you hope to benefit from this study?

……

……

……

2. How do you think your incorporation of Kahoot! gamification technology could assist you in teaching Probability lessons?

……

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3. **Explain what pedagogical changes would you implement in-order for you to be able to use Kahoot gamification technology to facilitate the learning of Probability?**

……

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……

4. **What challenges have you experienced in your incorporation of Kahoot! Gamification in teaching and how could you address them?**

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5. **How do you think your whole school community could benefit from the use of Kahoot! to facilitate teaching and learning?**

……

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Appendix C: Observation Guide

OBSERVATION GUIDE

The observations will have the same duration of the lesson period and it will occur one time with each teacher within classroom environment. I will be a non-participant observer and I will be observing the following aspects:

- The way teachers conduct their lessons
- What tools (for example, technologies) they use to interact with learners
- How the teacher will be handling or operating these tools

Part A Teachers Profile

Current profession…… **Position**……

Age ……... **Gender**……...

Years of teaching experience……. **Grades taught**……

Subjects……

Place of em**ployment** …… **Region**……..

Social- interactions	
Measure	Notes
Teacher- Learner interactions.	
Learner activities promoting participation.	
Learner's opinions considered	
Questions and responses from learners considered.	

Teacher encourages learner's participation.	
Teacher allows learners to talk more.	
Teacher's Pedagogical Knowledge	
Measure	Notes
Consider learner's prior knowledge	
Teacher demonstrates to learners how to carry out Kahoot! games	

Teacher's clarity of instructions	
Teacher ensures that all learners have logged in and are participating in games.	
Teacher's Technological Knowledge	
Measure	Notes
Teacher selects and generates appropriate quizzes that are suitable for the content.	
Teacher demonstrates confidence in using gamification technology to teach.	
Teacher uses Kahoot! with little or no problems.	

Observer's name_____ Date _____ Signature_____

Teacher's name_____ Date_____ Signature _____

Appendix D: Semi-structured Interviews

Interview Code : _____

Date and time : _____

Introduction

I, Ayanda Mbete am a part-time student doing Master of Education in ICT in Education with Rhodes University, South Africa (Student No). I am conducting research on using Kahoot! as a gamification technology to mediate learning of Probability in Mathematics. Would you be comfortable to share your thoughts with me?

Please take note of the following:

- This interview may take us between 30 minutes to 40 minutes to complete all the questions.

- You are not forced to answer all the questions.
- If you are not comfortable with a question, please indicate so.
- If you can no longer continue being interviewed for any reason, please feel free to inform me in the course of our conversation.
- Please indicate whether you need a short break in the course of the interview.
- I will be recording your voice if you allow me to do so.
- I will be taking notes including quotes from what you will be saying.
- Before the interview, during the interview and at the end of the interview, feel free to ask me questions that you would like clarifications about this study.

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1. How did you experience using Kahoot! as a gamification technology in your classroom to facilitate the learning of Probability in Mathematics?
2. During your lesson delivery with Kahoot! Gamification, have you experienced any changes in the way you delivered the lesson? Please elaborate and give an example
3. Do you think there is a link between the use of Kahoot! as a Gamification Technology and the teaching of Probability in Mathematics? Why?
4. Would you prefer to continue using Kahoot! in facilitating teaching of mathematics lessons in classroom and why?
5. Did you gain any new technological knowledge and experiences that supported to you to further or innovate ways of teaching Probability lesson? Please elaborate and give an example
6. Did you gain any new technological pedagogical knowledge and experiences that supported to you to further or innovate ways of teaching Probability lesson? Please elaborate and give an example
7. In your own experience is there any difference in the transmission of knowledge to learners when using the traditional approach to teaching and when using Kahoot! gamification?
8. In your experience what factors do you think was advantageous and disadvantageous about the use of gamification technology in teaching Probability?
9. What did you find challenging in your use of gamification technology in teaching Probability?
10. What factors could inhibit teachers from using of gamification technology in teaching?
11. What do you think should be done to make effective use of gamification technology in teaching of Mathematics, Probability in particular?

12. Is there any information that you would like to share with me related to this interview that I have not captured in my questions?

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Appendix E: Ethical Clearance

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 8208
email: e.rosenberg@ru.ac.za

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

13/12/2020

Dr Clement Simuja and Ms Ayanda Mbete-Matyantya

Education Department

C.Simuja@ru.ac.za and

Dear Dr Clement Simuja and Ms Ayanda Mbete-Matyantya,

Re: Gamification technology in teaching: Exploring how teachers make use of Kahoot! gamification to facilitate learning of Probability in their classrooms.

APPLICATION NUMBER: 2020-1521-4742

This letter confirms that your research ethics application has been reviewed and **APPROVED** by the Education Faculty Research Ethics Committee (EF-REC). Your permission letter(s) from the principals and the Eastern Cape Department of Education 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 to your Rhodes address 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. 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.

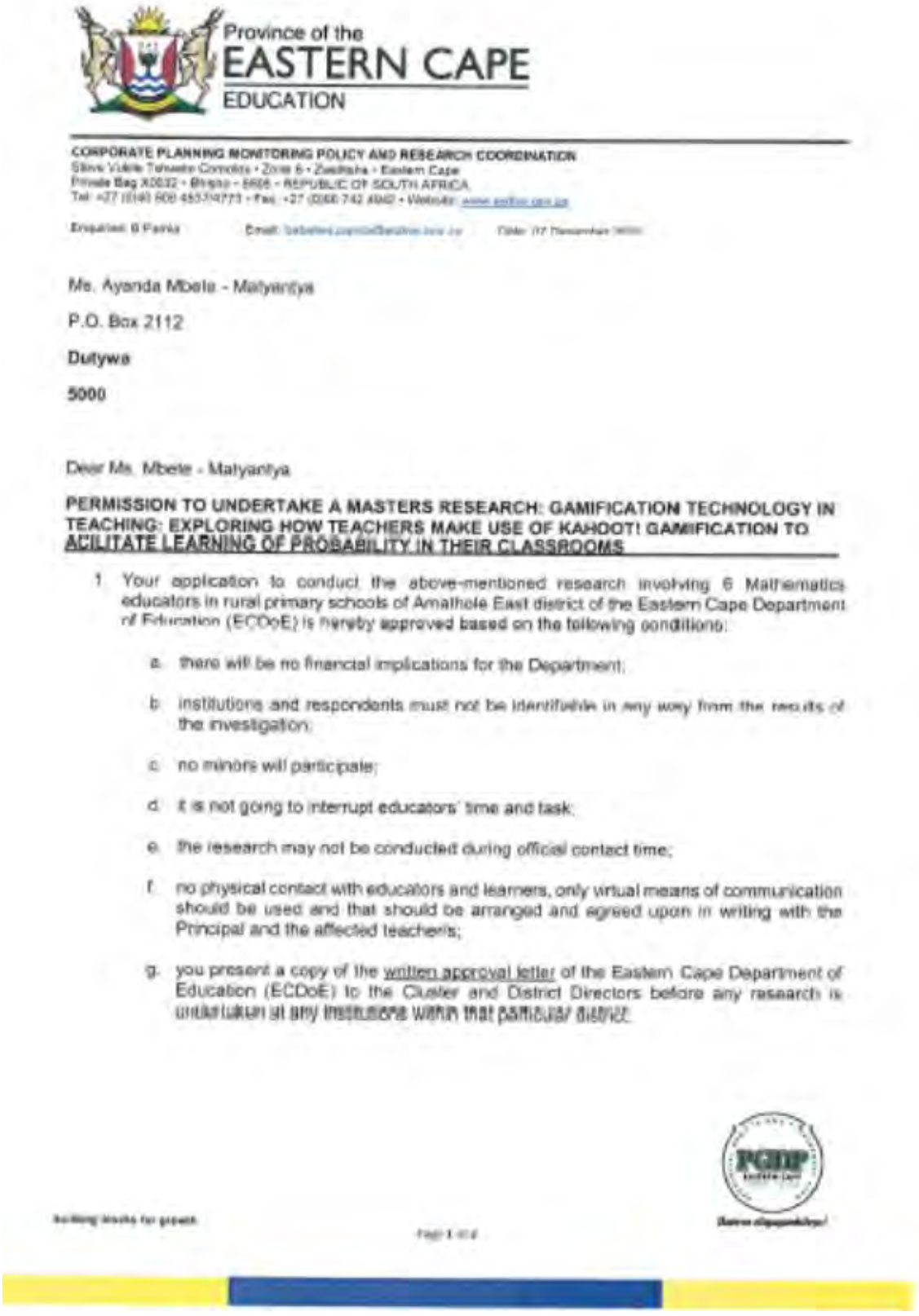
Please also submit a brief report to the REC Chair on the completion of the research. This can be done via email. The purpose of this report is to indicate whether the research was conducted successfully and whether any ethics-related matters arose that the committee should be aware of, in order to guide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

Sincerely,

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee

Appendix F: DoE Permission Letter



Province of the
EASTERN CAPE
EDUCATION

CORPORATE PLANNING MONITORING POLICY AND RESEARCH COORDINATION
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4553/4773 • Fax: +27 (0)86 742 4942 • Website: www.ecdoe.gov.za

Enquiries: S Fanisi Email: [illegible] Date: 07 [illegible]

Ms. Ayanda Mbele - Matyantya

P.O. Box 2112

Dutywa

5000

Dear Ms. Mbele - Matyantya

PERMISSION TO UNDERTAKE A MASTERS RESEARCH: GAMIFICATION TECHNOLOGY IN TEACHING: EXPLORING HOW TEACHERS MAKE USE OF KAHOOT! GAMIFICATION TO ACILITATE LEARNING OF PROBABILITY IN THEIR CLASSROOMS

1. Your application to conduct the above-mentioned research involving 6 Mathematics educators in rural primary schools of Amathole East district of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:

   a. there will be no financial implications for the Department;

   b. institutions and respondents must not be identifiable in any way from the results of the investigation;

   c. no minors will participate;

   d. it is not going to interrupt educators' time and task;

   e. the research may not be conducted during official contact time;

   f. no physical contact with educators and learners, only virtual means of communication should be used and that should be arranged and agreed upon in writing with the Principal and the affected teachers;

   g. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district.

PGMP

building blocks for growth

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h. you will make all the arrangements concerning your research;

i. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Corporate Strategy Management;

j. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis;

k. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary;

l. you are requested to provide the above to the Chief Director: Corporate Strategy Management upon completion of your research;

m. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you;

n. you comply with your ethical undertaking (commitment form);

o. You submit on a six-monthly basis, from the date of permission of the research, concise reports to the Chief Director: Corporate Strategy Management.

2. The Department reserves a right to withdraw the permission should there be non-compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDoE and/or legal requirements to do so.

3. The Department will publish the completed Research on its website.

4. The Department wishes you well in your undertaking. You can contact the Mrs. B Pamla on the numbers indicated in the letterhead or email babalwa.pamla@ecdoe.gov.za should you need any assistance.

T MASOEU
CHIEF DIRECTOR: CORPORATE STRATEGY MANAGEMENT

FOR SUPERINTENDENT-GENERAL: EDUCATION

Appendix F: Letter to Principals

A letter to the principal

To : The Principal

……. School

Amathole East Education District

From : A. Mbete -DCES TLTE

: Request for permission to conduct educational research with Grade 6 teachers in your schools on utilisation of Kahoot! gamification technology to facilitate learning of Probability in Mathematics.

I, Ayanda Mbete am a part-time student doing Master of Education in ICT in Education with Rhodes University, South Africa (Student No). I am a Deputy Chief Education Specialist (DCES) for Telecollaborative Learning and Technology Education (TLTE) and I am coordinating e- Learning across curriculum at Amathole East district. I hereby humbly request your permission for me conduct a research study with a teacher at your school to be my research participant in my research project. I plan to conduct the study for about six weeks in May/June 2020.

South Africa is always in the lowest rung of ladder in the international studies for mathematics performance across the Grades as revealed by TIMSS reports. Also, the DBE diagnostic report for Grade 12 class of 2019 reveals that Probability is the most underperformed question in the final examination as it recorded only 21 %. Furthermore, according to the Amathole East district 2018 and 2019 question by question analysis of common tasks for the fourth term for Grade six, learners poorly perform Probability even though it constitutes less marks than other topics. The CAPS document for Grade 6 requires the use of a dice, a coin and a spinner for learners to understand Probability. Probability is one of the accumulative topics and I feel that the resources prescribed for teaching Probability are limited and it is against this backdrop that I opt to engage in an interventional study to explore the incorporation of Kahoot! as a gamification technology in the teaching and learning of Probability. This research has been approved by both the Rhodes University Ethical Standards

Committee and the Education Department Higher Degrees Committee. During the research any concerns may be directed to Mr. Siyanda Manqele, Ethics Coordinator, Research Office, Rhodes University +27 (0) 46 603 7727, s.manqele@ru.ac.za. The study is under the supervision of Doctor Clement Simuja (E-mail: c.simuja@ru.ac.za). I would further like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. Identity of participants and their views will be treated with the highest degree of confidentiality and anonymity.

Your consideration in this regard will be highly appreciated.

Yours Sincerely,

Ayanda Mbete (Master of Education in ICT in Education)

Declaration

I..... (Full names of the principal) hereby confirm that I understand the content of this document and the nature of this research study. I give permission for my educator to participate in the interventional study at Amathole East District in 2020.

....

The Principal Date

Amathole East Education District

School Stamp

Appendix G: Letter to teachers

Letter to teachers (Participants)

To : (Name)

……. School

Amathole East Education District

From : A. Mbete -DCES TLTE

Re : Participation in research on using Kahoot! Gamification technology to mediate learning of Probability in Mathematics.

I, Ayanda Mbete am a part-time student doing Master of Education in ICT in Education with Rhodes University, South Africa (Student No). I am a Deputy Chief Education Specialist (DCES) for Telecollaborative Learning and Technology Education (TLTE) and I am coordinating e- Learning across curriculum at Amathole East district. I hereby humbly request your permission to be a research participant in my research project. I plan to conduct the study for about six weeks in May/June 2020.

The focus of the study will be on *using Kahoot! Gamification technology to mediate* learning of Probability in Mathematics and it will be conducted in four phases. The first phase will involve questionnaires to find out your technological experiences and pedagogical insights and attitudes towards use of gamification technology. In the second phase there will be an orientation workshop of which I am going to give an overview of the study and the training on the utilization of Kahoot! Gamification technology. Phases 3 will involve myself observing you making use of Kahoot! In mediation of learning in your classroom. Phase 4 will involve myself interviewing you on your overall experience in the utilization of Kahoot! As a gamification technology to mediate the learning of Probability in Mathematics.

Your participation in this research study is completely voluntary and you can withdraw at any time you wish. I ask for your permission to make voice recordings of the interviews so that I can be able to analyse the data later. I will ensure that your identity and views will be treated with high degree of confidentiality and anonymity, and data that will be collected will not be used for other purposes apart from this study.

This research has been approved by both the Rhodes University Ethical Standards Committee and the Education Department Higher Degrees Committee. During the research any concerns may be directed to Mr. Siyanda Manqele, Ethics Coordinator, Research Office, Rhodes University +27 (0) 46 603 7727, s.manqele@ru.ac.za or my supervisor Doctor C. Simuja c.simuja@ru.ac.za.

Consent: I am aware that

- I will be the participant for the above-mentioned topic.
- I am willing to be interviewed, observed and engage in workshop discussions.
- I am willing to write reflective journals and participate in questionnaires.
- I am free to withdraw at any time I may wish without negative or undesirable consequences.
- 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
- I am aware that the findings will be reviewed in the research thesis.
- My identity in this study will be protected with the code of ethics stipulated by Rhodes University
- Having taken note of the above information, I freely and volunteer to take part 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 Sincerely

Ayanda Mbete

Master of Education in ICT in Education