# RHODES UNIVERSITY

**EDUCATION DEPARTMENT**

***Where Leaders Learn***

PROMOTING GRADE 9 MATHEMATICS TEACHERS' TPACK DEVELOPMENT THROUGH PLANNING ALGEBRA LESSONS THAT INTEGRATE TECHNOLOGY IN OSHAKATI EDUCATION CIRCUIT

By

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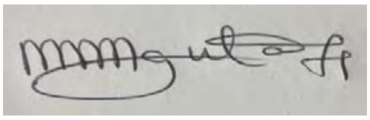
## DECLARATION

I, *Mechtilde Angula*, declare that the contents of this thesis represent my unaided work and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Rhodes University.

Signed:  Date: 28 January 2024

# ABSTRACT

The revised curriculum in Namibia highlights the integration of digital tools to help learners understand mathematics better. For this purpose, teachers need to possess Technological Pedagogical Content Knowledge (TPACK) to utilize technology effectively. However, using technology by itself does not guarantee better learning rather, it requires an understanding of how to integrate technology in teaching mathematics. Therefore, this case study explored Grade 9 mathematics teachers' TPACK development through planning algebra lessons that integrate technology. An interpretive paradigm, supported by a pragmatic paradigm, underpins the study, and a qualitative case study approach was employed. The study purposively engaged ten Grade 9 mathematics teachers from four schools in Namibia. Demographic questionnaires, Semi-structured interviews, Reflective journals, notes from discussions, focus group interviews and document analysis were used to gain teachers' insights on TPACK development. The study was guided by two educational theories: Bernstein's Sociology of Education (1971) and Bloom's Taxonomy of the Cognitive Domain (1956). Also, Mishra and Koehler's TPACK framework (2009) was used to analyze the data. The findings showed that mathematics teachers had a positive view of technology integration in mathematics lessons and TPACK development through technology-integrated lesson planning, but they lacked the knowledge for planning lessons that integrate technology. Taking part in the intervention improved the selected mathematics teachers' understanding of TPACK, making them more confident about using technology in their teaching. The study also found different strategies to help teachers incorporate technology into their lessons, along with having a strong grasp of the subject and effective teaching methods. Based on these findings, it is suggested that in-service mathematics teachers take part in interventions focused on integrating technology into lesson planning. These interventions should demonstrate how technology can improve mathematics education and how it fits with both content and teaching methods. It is also recommended that these interventions emphasize the importance of Bloom's Taxonomy in using technology for mathematics education. The study concludes by suggesting further research on how planned lessons can be implemented in actual mathematics classrooms.

**Keywords:** Algebra, Bernstein Theory, Mathematics Education, Technology Integration, TPACK

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I would like to express my gratitude to all the contributing members, ranging from the proofreading team to the editing and structure organizing team. Your constructive feedback and comments were necessary, and I sincerely appreciate your contributions to refining my work.

# DEDICATION

This thesis is dedicated to my beloved late mother,

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Your death has cut a deep bleeding wound in my heart. At first, I was left with many concerns about how to lay a good life example to my siblings. I am forever grateful for your love and the lessons you taught me about life. You were such a loving mother. Your leaving has shown me that God selects the finest individuals, always with a purpose behind every occurrence and ensuring that we lack nothing in the broader scheme of things. The unconditional love, steadfast support, and constant encouragement you provided during your lifetime will sustain me for the rest of my life.

## LIST OF ACRONYMS AND MEANINGS

| ACRONYMS | MEANING |
|---|---|
| CK | : Content Knowledge |
| CPD | : Continuous Professional Development |
| HOTS | : Higher Order Thinking Skills |
| ICDL | : International Computer Driver's License |
| ICT | : Information Communication Technology |
| LAT | : Learning Activity Type |
| LOTS | : Lower Order Thinking Skills |
| MoEAC | : Ministry of Education, Arts and Culture |
| NIED | : National Institute for Educational Development |
| PCK | : Pedagogical Content Knowledge |
| PK | : Pedagogical Knowledge |
| SAMR | : Substitution Augmentation Modification Redefinition (SA |
| TAM | : Technology Acceptance Model |
| TCK | : Technological Content Knowledge |
| TK | : Technological Knowledge |
| TPACK | : Technological Pedagogical Content Knowledge |
| TPK | : Technological Pedagogical Knowledge |

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## 1.1 Introduction to the study

The advent of digital technology has dramatically changed the routines of most arenas of human work (Chiu, Lin, & Lonka, 2021), which has compelled technology advocates to expect similar influences in the education process (Nagel, 2020). According to Erbilgin & Sahin (2021, p.2) "today's teachers are teaching a generation of learners who were born in a digital world and experienced using a variety of digital technologies." This suggests that the diffusion of technology in any educational setting need to be considered carefully (Chiu et al., 2021; Karakaya, 2017). Similarly, integrating technology as an organic part of teaching and learning is becoming paramount to how teachers plan and integrate new technologies into mathematics education, particularly in algebra lessons (Al-khresheh, 2022; Ritter, 2012).

In response to the technological demands, some mathematics teachers are incorporating technologies in their teaching practices to support learners in mastering basic competencies and solving life problems through mathematics reasoning (Abidin, Herman, Jupri, & Farokhah, 2021). However, mathematics is considered an abstract subject that is considered difficult to teach (Mukuka, Shumba, & Mulenga, 2021; Ying, Wijaya, & Ya, 2020). Some studies highlighted the difficulties of learners learning algebra topics (Pramesti & Retnawati, 2019; Rompas, et al, 2023; Ying, et al, 2020). All mathematics instruction, and algebra instruction in particular, should be designed to promote understanding of concepts and encourage critical thinking. Therefore, Subia (2018) cautions that teachers need to use innovative, practical teaching methods in teaching algebra.

However, literature contends that the use of technology offers pedagogical affordances for practical learning (Bray & Tangney, 2016; Perienen, 2020). Moreover, the integration of technology in algebra lessons could help teachers to design interesting engaging lessons (Wijaya, et al., 2022) and thereby facilitate learners in overcoming obstacles to learning through practical activities rather than memorization (Elmi, 2020). Consequently, teachers require a specialized understanding to effectively integrate technology. It is important to note that, similar to any educational resource, the mere utilization of technology in lessons does not guarantee success independently. However, Improved learning outcomes can be obtained when technology is used to promote higher-order thinking skills, metacognition, and communication in the classrooms (Kim, Yi, & Hong, 2020; Tong et al., 2021). Consequently, there is an increasing need for mathematics teachers to acquire knowledge of technology as a complementary element in ensuring effective technology integration (Cao,et al., 2021).

Furthermore, several scholars posit that the integration of technologies in teaching is significant in algebra lessons (Kiru, 2018; Stein, Gurevich, & Gorev, 2020). This is because although technology has a relationship with many fields, it has a privileged and prominent place in mathematics. It is worth noting that, mathematics classrooms are a natural place for technology use since so much of mathematics modelling nowadays depends on technology (Jablonka, 2020). Therefore, integrating technologies in algebra lessons becomes central to providing authentic mathematics learning experiences (Yaniawati, et al., 2020). This is because most algebra concepts are linked to other mathematics topics that align with current issues and real-world experiences.

On the other hand, Harris and Hofer (2011, p.99) suggest that “integrating educational technologies into instruction, teachers’ planning must occur at the nexus of standards-based curriculum requirements, effective pedagogical practices, and available technologies’ affordances and constraints.” This implies that appropriate planning is necessary when designing algebra lessons that integrate any technology to achieve curricular goals. However, Valverde-Berrocoso, Fernández-Sánchez, Revuelta Dominguez and Sosa-Díaz, (2021) emphasized that effective integration of technologies in lesson planning and delivery can be a complicated process, leading to further disparities and challenges in the teaching and learning. Thus, introducing technologies into lesson planning inevitably adds another layer of complexity to the lesson preparation process (van Kraalingen, 2021).

As Gentles and Haynes-Brown (2021) observed, planning lesson activities that incorporate technology is an arduous and complex job given the multiple sources of knowledge that need to be contextualized and negotiated. This complexity of integrating technologies in lesson activity planning brings to the forefront a new type of teacher knowledge that would encompass the knowledge of technology, pedagogy, and content. Similarly, Mishra and Koehler (2006) suggest that technology integration into mathematics teaching can only occur when the teacher possesses a specialized form of knowledge, technological pedagogical content knowledge (TPACK). TPACK describes a teacher's knowledge foregrounded in an intricate understanding of the complex transactions between technology, content, and pedagogy. Teacher capitalize on this understanding to craft suitable and context-specific teaching approaches. Therefore, TPACK serves as the cornerstone of effective teaching with technology in mathematics. This requires the knowledge of theories of epistemology and how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones' (Mishra & Koehler, 2006, p.32). Therefore, this study assume that possession of technological pedagogical content knowledge by Grade 9 mathematics teachers would mean that the teachers could effectively enhance their teaching through the opportunities offered by successful technology integration.

## 1.2 Background of the study

The importance of mathematics knowledge and skills in the technology age is vital for the development of critical reasoning (Iithete & Hiloshi, 2021; Maass, Geiger, Ariza, & Goos, 2019). According to the Namibian National Institute for Education Development (NIED), the Namibian revised curriculum demands learners to have mathematics as a school subject from grade 8 to 11, compared to the old syllabus. However, in Namibia, Algebra is considered one of the most difficult topics to learn among school learners (Anderson, 2019; Hamukwaya & Haser, 2021). One contributing factor is the pressure brought forth by the recently revised curriculum, which made new changes to the curriculum content. Some changes made are noted by, Bezuidenhout (2021, p. 2) that,"high-level algebra concepts are introduced so early in grade 9, which is an exit point to the secondary phase".

However, as an attempt to ease the new curriculum pressure, the Ministry of Education, Arts, and Culture (MoEAC) conducted curriculum orientation workshops to introduce teachers to some of the perceived difficult curriculum topics in mathematics from grades 8 to 12 (Angula, 2019; Josua, 2022). Consequently, "from 2016, after the revision of the curriculum, several professional development workshops funded by the MoEAC took place. 'These workshops again used the cascade model to enhance mathematics teachers' subject content knowledge in preparation for the implementation of the revised curriculum'" (Kanandjembo, 2022, p. 10). Although content and pedagogical-orientated workshops were initiated, the literature suggests that learning mathematics requires learners to be engaged in effective teaching and learning activities to master complex concepts (Benton, Saunders, Kalas, Hoyles, & Noss, 2018; Mulenga & Marbán, 2020). Similarly, Bezuidenhout (2021) contends that there is a need for additional teaching resources for teaching mathematics in schools, specifically with the new curriculum introduced in Namibia.

Similarly, Keengwe (2020) recommends teachers adopt 21st-century pedagogical approaches that value the use of technology in teaching and learning of mathematics. Moreover, some teachers in Namibia do believe that technology can afford learners to participate in various learning activities at any time and from anywhere (Jatileni, 2018; Nanotek & Benu, 2022). To support that literatures, highlighted that technological tools such as radio, TV, Internet, computers, laptops, tablets, and many other hardware and software applications can be appropriated in the teaching-learning process (Das, 2019; Shareef, & Nithyanantham, 2022). This implies that technological tools can offer the effective presentation of content, curriculum, instruction, and assessment when effectively integrated into algebra lessons.

The MoEAC, in conjunction with non-governmental organizations, introduced initiatives that are furbishing schools with technologies such as computers, laptops, Internet, and computer laboratories. More to this, the MoEAC introduced various technology training programs, such as the Technology Namibia (Tech/NA), International Computer Driver's License (ICDL) workshops and Educational digital skill training. Some of the mathematics teachers may or may not have attended these workshops or training. Although the technology training workshops are essential, this approach to teacher development, including mathematics teachers, seems to suggest that teachers should merely be trained to use the technology. The anticipation however is that, by demonstrating technology skills to use the various hardware and software, the teachers will be able to effectively integrate technologies into their teaching. Nonetheless, not only providing teachers with technology knowledge supported efficient training is considered important. As Mishra and Koehler (2006) also note, technological knowledge needs to be related to pedagogical and content knowledge.

Hence without technological pedagogical content knowledge, the implementation of technological knowledge alone presents many more intrinsic difficulties in curriculum planning for lessons that infuse technology. Therefore, literature caution that teachers' pedagogical content knowledge must be expanded to include specialized knowledge on planning, choosing, and using a broad range of educational technologies appropriately within different content areas and teaching approaches (Elas, Majid & Narasuman, 2019; Hill & Uribe-Florez, 2020; Ritter, 2017). Thus, careful planning must be paramount to integrating any technology within a lesson plan or in the decision-making process to achieve curricular goals. In the context of education in Namibia, teachers, particularly mathematics teachers, appear to incorporate technology integration as a component of their cognitive processes during lesson planning. However, it is imperative to examine how teachers develop TPACK as they plan to integrate technologies into their instructional activities.

### 1.3 Statement of the problem

The Namibian national curriculum requires teachers to integrate technology in teaching and learning across all subjects. However, the curriculum document lacks clear guidelines on how and where technology should be integrated into mathematics lessons. Although the Namibian government, through the MoEAC, is encouraging teachers to integrate technologies in the classroom, my observation and experience as a mathematics teacher concur with Jacob, John, and Gwany (2020) that most mathematics teachers lack the necessary knowledge to select appropriate contextual authentic technologies to best serve the algebra teaching process. Subsequently, despite the prevalence of professional development opportunities targeting technology, the use of technological strategies and knowledge to plan, deliver, and assess lessons remains a significant challenge to most mathematics teachers (Nasr, 2020; Ngololo et al., 2022).

Consequently, some mathematics teachers use technologies just because they are available at the school. As observed by Walker (2021) that the teacher's bias, efficacy, lack of technological integration knowledge, access and other factors have resulted in technology uses as a last minute add on or used as an incoherent or ambiguous fragment of a unit or lesson plan. This poses many challenges for most mathematics teachers in Namibia in developing curriculum or algebra lesson activities that best integrate technology (Ashipala, 2021; Kambeyo, 2018).

The Namibian revised curriculum, which was concluded in grade 12 for the academic year 2020, has presented significant challenges in the education sector (Bezuidenhout, 2021). One notable issue is the teacher-learner ratios, especially its impact on mathematics education. The new curriculum has brought forth grade 10 to be moved from combined schools to secondary schools (Boer & Asino, 2022). Many combined schools, particularly those in rural areas, decreased in the learners' enrolments, while urban schools became overcrowded. This did not only strain resources in the crowded schools but also placed a heavy teaching load on teachers in densely populated classrooms. In contrast, schools with lower enrolments are faced with the challenge of teaching multiple subjects to meet the required learner-teacher ratios.

To illustrate, the National curriculum for basic education policy (2015), demands that mathematics grade 9 should be taught seven lessons on a seven-day cycle to a ratio of 30 learners per teacher. The policy requires teachers to teach 8 lessons per day which accounts to 40 lessons per week (MoEAC, 2015). Consequently, teachers like myself teaching in an overcrowded school are finding themselves tasked to teach mathematics to eight similar grades with multiple classes (i.e., grade 9A to grade 9F), each class consisting of 30 learners. This makes it easy to achieve the policy requirement by teaching 8 similar grade per day. While teachers in some schools with lower enrolments, finding themselves teaching mathematics to different grades because there are no many same grades at school. Now that the policy demands them to teach 8 lessons per day, they are forced to teach different grades. For instance, a teacher in low enrolment school could end up teaching mathematics to grade 6 (with 19 learners), grade 7 (with 16 learners), grade 8 (with 18 learners), and grade 9 (21 learners), resulting in teachers struggling to achieve the required amount of 8 lessons per day and a ratio of teaching 30 learners per class per teacher. As a result, some teachers end up teaching different subjects to achieve the required lessons per day. This situation is regarded as overstaff, which means, there are many teachers than learners because the learner teacher ratio in Namibia at secondary level is 30 learners per teacher which implies 30 learners per class (MoEAC, 2015).

The overstaff situation has bought pressure in planning for lesson activities in schools with few learners. For instance, when it comes to planning the first assessment test for the term, as one of the teachers in the overcrowded school I only subjected to prepare one test for all eight grade 9 classes (the grade contains classes A to F), whereas the teacher in the less enrolled schools is obligated to plan four different tests for four different grades, in order for each grade to write the first test for the term. This teacher may end up planning about 12 tests, despite the prevailing policy claiming the school to be overstaffed. This situation has rendered the task of planning lesson activities intricate and perplexing as teachers grapple with differing assessment schemes and syllabi, ultimately compromising the quality of the devised planned lesson activities.

Moreover, as a leader of the Continuous Professional Development (CPD) committee in Oshakati Education Circuit and a mathematics teacher with ten years of experience teaching in Namibian schools, I observed that most teachers lack the knowledge to plan for effective instruction in which educational technologies are well-integrated. Consequently, improper planning for lessons that integrate technology poses significant consequences, such as poor mathematics understanding among learners or teachers' failure to meet educational goals (Ahdhianto & Santi, 2020). Therefore, it is becoming increasingly critical for mathematics teachers in Namibia to develop the necessary knowledge and skills to integrate technology into their curriculum and lesson planning. Thus, the assumption in this study is that fostering mathematics teachers' technological pedagogical content knowledge might allow for effective algebra instructional planning. It is assumed in this study that teachers need to decide on the technological tools based on the lesson objectives, learning needs, subject policy and accessibility to available devices. As a result, the teacher would only be able to plan to use technological tools if they know the relationship between content, pedagogy and the technological tool available (Harris & Hofer, 2011; Koh & Chai, 2014; Santos & Castro, 2021).

However, researchers have made it explicitly clear how context plays an integral part in technological pedagogical content knowledge because every form of teacher knowledge is situated and contextually sensitive (Harris & Hofer, 2009; Kulaksız & Karaca, 2022; Mishra & Koehler, 2008). Although limited research has been done in the areas mentioned in Namibia (Jatileni & Jatileni, 2018; Leite & Lagstedt, 2021; Nchindo, 2019; Ngeama, 2018), the current literature does not offer insight into how mathematics teachers develop technological pedagogical content knowledge during algebra lesson planning. Therefore, this study envisages that a need exists to conduct an intervention study that seeks to develop mathematics teachers' TPACK during the lesson planning process. Hence this study seeks to explore Grade 9 mathematic teachers' TPACK development through planning algebra lessons that integrate technology in the Oshakati education circuit, Namibia.

## 1.4 Purpose and significance of the Study

The study intended to explore an intervention inquiry on how grade 9 mathematic teachers could develop TPACK as they plan algebra lessons that integrate technologies. It is envisaged that this intervention study may fill the gap in knowledge for developing grade 9 mathematics teachers' technological pedagogical content knowledge in the Oshakati circuit. Working collaboratively towards a shared goal of developing TPACK in this study as a professional learning space may equip the teachers to be involved in supporting one another within, across and beyond schools, as suggested by Ngcoza and Southwood (2019). The knowledge gained from this study on Grade 9 mathematics teachers' TPACK development may also be transferred to other related school subjects.

The study might contribute to the limited literature on the development of TPACK when planning lessons that integrate technology in Namibian schools. Additionally, it would reflect Bloom's taxonomy theory and Bernstein's theory as an uncommon theory used in studies related to TPACK development. This would offer a magnified view and further understanding of the development of TPACK for effective integration of technology in education at large. The findings from this study may assist the continuous professional development committees to address the information communication technology (ICT) development needs of teachers in Oshakati education and other similar regions' education circuits. Furthermore, the study findings may point out how mathematics teachers in the Oshakati circuit can be supported to develop technological pedagogical content knowledge when planning teaching and learning activities that integrate technology.

## 1.5 Research goals

The research goals aim to delve into or elucidate the purpose of the research investigation Dawadi, Shrestha and Giri (2021), which may stem from a research gap and opportunity that exist from previous researchers (Ridder, 2017).

**(a) Research objectives**

This study mainly seeks to explore Grade 9 mathematics teachers' TPACK development through planning algebra lessons that integrate technologies in Oshakati education circuit.

- To explore how Grade 9 mathematics teachers describe their process in planning lessons that integrate technology in the Oshakati education circuit.

- To understand how planning lessons that integrate technology offer or not the opportunity for Grade 9 mathematics teachers to develop technological pedagogical content knowledge in the Oshakati education circuit.
- To recommend how Grade 9 mathematic teachers can be supported to develop technological pedagogical content knowledge as they plan algebra lessons that integrate technology.

**(b) Research Questions**

To achieve the goal, the following research questions were considered:

1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology in the Oshakati education circuit?
2. What opportunities are offered or not to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology in the Oshakati education circuit?
3. How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning lessons that integrate technology?

## 1.6 Definition of terms

For clarification purposes, the researcher chose to offer a brief explanation of the following key terminology used in the research purpose, objectives and main question and sub-questions: ICTs, Context, Technological Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, Technological Pedagogical Content Knowledge and professional development, Algebra.

**ICTs**: Information and communication technologies, which characterize the amalgamation of information technology and communication technology (South Africa, 2004:42). White paper 7 (South Africa, 2004) states that ICTs are a combination of hardware, software and communication media which enables the processing, administration and exchange of data, information, and knowledge.

**Context:** Context is defined as subject matter, grade level, student background, available technologies, the design and characteristics of learning environments, supporting elements available in the school, and societal conditions such as state and national standards (Kelly, 2008; Mishra & Koehler, 2006; Rosenberg & Koehler, 2015).

**Technological Knowledge (TK):** Knowledge of basic technologies (i.e., books, chalks) and digital technologies (i.e., Internet, hardware, software) to accomplish the targeted task (Mishra & Koehler, 2006).

**Technological Content Knowledge (TCK):** Knowledge of understanding the technology and content how they influence and constrain each other (Mishra & Koehler, 2006).

**Technological Pedagogical Knowledge (TPK)**: Knowledge of how to use specific technologies in specific ways to change learning and teaching. Knowing the pedagogical benefits and constraints of technologies (Mishra & Koehler, 2006).

**TPACK:** Knowledge of the interaction of content, pedagogy, and technology. Being able to teach specific content with specific techniques and methods and appropriate technologies (Mishra & Koehler, 2006).

**Professional Development**: The ICT integration training teachers receive, and the devices-usage training is considered part of the teachers' professional development.

**Algebra:** is the branch of mathematics that represents problems in the form of mathematical expressions.

### 1.7 Structure and organization of the study

This study is divided into six detailed chapters. These chapters explore the specific aspects of enhancing the development of the knowledge of using technology in teaching algebra to Grade 9 mathematics teachers. Each chapter provides a different viewpoint and brings a unique contribution to the overall study.

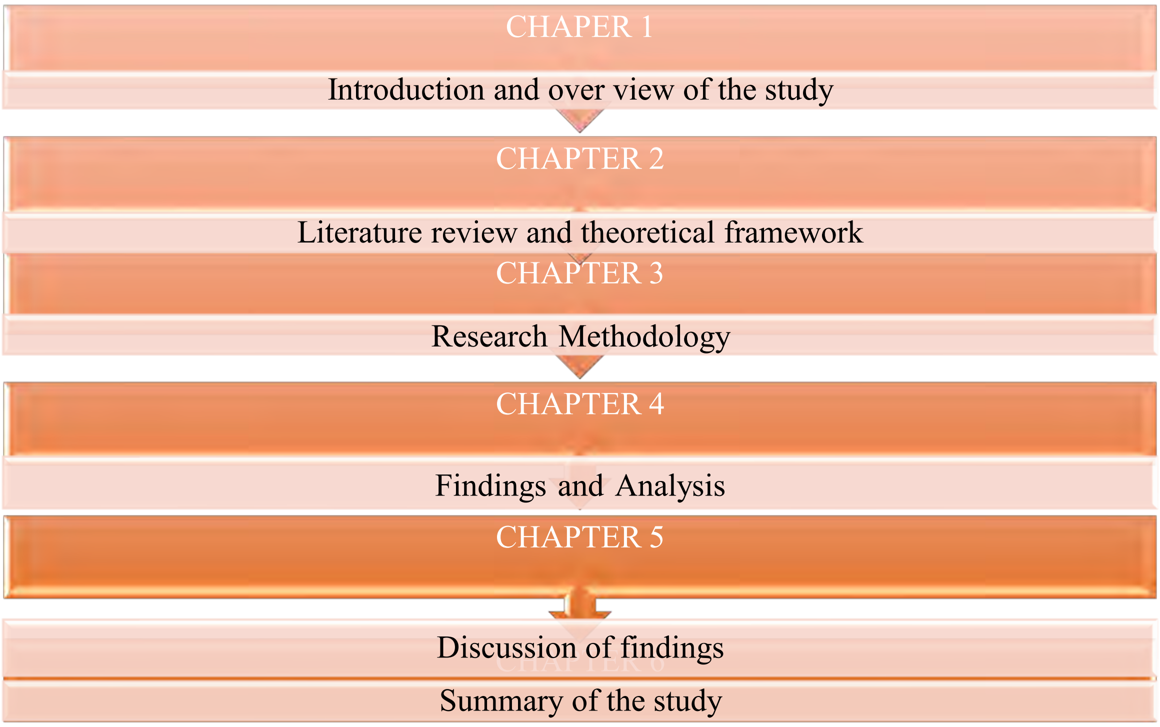


*Figure 1.1: Structure of the study*

The following is a brief outline of the contents covered in each chapter.

- **Chapter One** gave an introduction to the study with reference to its background, objectives, and significance. Specifically, the main concepts of the study were considered in its international and local contexts in this chapter. Additionally, it covers the research questions and the content of the subsequent chapters in the study.

- **Chapter Two** presents a comprehensive review of the most current and pertinent literature pertaining to this study. The process of conducting the literature review has been scrutinized in light of the research questions outlined in the previous chapter of this study. The reviewed literature has been sourced from reputable electronic databases such as Google Scholar, Research Gate, Science Direct, and various relevant websites. Additionally, this chapter expounds upon the theoretical frameworks employed to enhance the depth of understanding in this study. Specifically, Bernstein's theory, Bloom's Taxonomy theory, and the TPACK framework were utilized as theoretical and analytical underpinnings, respectively. The rationale for selecting two theories and one framework and their application in this study is explicated. Furthermore, this chapter assesses the Technology Acceptance Model (TAM) and the Substitution Augmentation Modification Redefinition (SAMR) model as alternative frameworks that could have been adopted, offering reasons for their exclusion in this particular study. The researcher acknowledges the limitations inherent to the TPACK framework employed as the analytical basis. Finally, this chapter culminates in a synthesis of the two theories and one analytical framework, elucidating how they complement and reinforce one another in the context of this study.

- **Chapter Three** provides a detailed account of the research design employed, situating it within the interpretive paradigm supported by a pragmatic research paradigm, utilizing a qualitative case study approach. The rationale behind endorsing the interpretative paradigm in conjunction with pragmatism and employing a qualitative design through a case study approach is expounded and justified. Furthermore, the chapter elucidates the sample size and the criteria used for sampling, offering rationale for these decisions. The strengths of the data generation methods, which encompass of demographic open-ended questionnaires, workshop discussions, journal reflections, field notes, document analysis, semi-structured interviews, and focus group interviews, are clarified, while acknowledging any associated limitations. This chapter establishes the coherence of the study, demonstrating how the methodology aligns with the research objectives and underscores the adequacy of the design and execution concerning the research questions and subsequent data analysis. Additionally, the chapter delves into the thematic data analysis process, as well as considerations of triangulation and research evaluation, emphasizing trustworthiness, credibility, transferability, and confirmability. Finally, the chapter concludes by addressing the ethical considerations inherent in this study.

- **Chapter Four** of the study presents the findings of the study. Data generated through demographic open-ended questionnaires, semi-structured interviews, workshop discussions, field notes, journal reflections, document analysis and focus group interviews were all at the centre of this chapter. The findings of the study, which are consistent with the methodology, are clearly and correctly presented in this chapter. The findings are presented according to themes that emerged from the analysis of the data based on the research questions. Considering the importance of dependability, great effort is made to provide teachers' responses in their own words so that readers would be convinced that the data generated had led to the findings presented by the researcher. Document analysis plays a major role in confirming whether teacher responses are in line with the policy requirements such as syllabus, subject policy and curriculum for triangulation purposes.

- **Chapter Five** initiates a discussion that thoroughly evaluates the outcomes, supported by existing literature reviewed in chapter two. It also provides an analysis of the findings with reference to established research. Additionally, it elucidates the importance of these findings. Expanding on the content of earlier chapters, this section extensively explores and explains the findings, linking them to the theories and framework and the wider context. Furthermore, this chapter addresses the initial research questions and objectives.

- **Chapter Six** offers conclusions derived from the responses to the research inquiries, identifies any limitations encountered, and suggests recommendations for future studies. It consolidates the main discoveries and their ramifications. It also reexamines the initial research aims and questions, explaining how they were addressed. Additionally, it proposes potential directions and recommendations for future research and exploration.

### 1.8 Summary for Chapter One

This chapter presented a compelling argument for the need to explore Grade 9 mathematic teachers' TPACK development through planning algebra lessons that integrate technology in Namibia. In addition, the chapter provided the background on the research problem, the objective of the study and the research questions, and the significance of the study. The chapter concludes by providing an overview of the subsequent chapters. The next chapter will focus on a literature review that is related to the main debates, trends, and gaps in the research topic.

## CHAPTER TWO: LITERATURE REVIEW

- 2.1 Introduction
- 2.2 Teaching and Learning of Algebra
- 2.3 Technology integration in mathematics teaching and learning
- 2.4 Profesional Development and Technology Integration
- 2.5 Planning algebra lessons that integrate technology
- 2.6 Teachers' TPACK Development and learning Activity type (LAT)
- 2.7 Theoretical framework
- 2.8 Summary of the chapter

### 2.1 Introduction

This study seeks to explore mathematics teachers' TPACK development through planning algebra lessons that integrate technology. The previous chapter discussed the background of the study, the problem statement, the purpose and significance of the study, the research goals, and the outline of the study. This chapter undertakes an in-depth examination and presentation of pertinent existing literature relevant to the study. Literature encompasses a compilation of published materials such as books, scholarly articles, and other sources about the central discussions, trends, and areas of research or interest (Giannakos, Mikalef & Pappas, 2021).

Furthermore, a literature review constitutes methodical and thorough scrutiny of literature pertinent to the research domain, with the aim of guiding the formulation of research questions and objectives (Aveyard, Payne & Preston, 2021). The relevant literature were sourced from reputable sources, including Google Scholar, Research Gate, Science Direct, government reports, and conference proceedings. This chapter draws upon the most recent and relevant antecedent literature regarding technological pedagogical content knowledge development when planning lessons that integrate technology. The primary goal of this literature review is to augment the researcher's comprehension for a better grasp of the existing body of research on the subject under investigation.

Literature facilitates the identification of existing gaps in the literature, providing a foundation for the rationale behind this study's contribution to advancing knowledge in the field. In this context, the researcher considers Hart (2018), who asserted that literature reviews acknowledge the contributions of other researchers in recognizing gaps and discrepancies in earlier studies (Breslin, & Gatrell, 2023) and situate this research within the broader context of existing literature, thereby making a compelling case for the significance of this study (Xiao & Watson, 2019).

This chapter consists of nine sections and begins with 2.1, introduction 2.2, teaching and learning of algebra 2.3, technology integration in mathematics teaching and learning 2.4, professional development 2.5 planning algebra lessons that integrate technology, 2.6, teachers' TPACK development and learning Activity Type (LAT) Followed by, 2.7 two theoretical frameworks and one analytical framework to underpin this study were identified, Bernstein, 1971; the Sociology of Education and Bloom's Taxonomy 1956: Cognitive domains, which assisted in the understanding the planning of lessons that integrate technology and TPACK framework which helped to understand the development of technological pedagogical content knowledge and Lastly 2.8, summary for this chapter.

**2.2 Teaching and learning of Algebra**

Algebra, as defined by D'Emiljo (2012, p.38), comprises a system of symbols and numerical values interconnected through operations such as addition, subtraction, multiplication, and division. Scholars posit that Algebra constitutes an indispensable facet of mathematical education, serving as a pivotal agent in nurturing students' proficiency in algebraic thinking and enhancing their capacity for mathematical reasoning (Kieran, 2004; Lugalia, 2015). This signifies that Algebra also functions as a potent mathematical knowledge employed for resolving practical, real-world challenges encountered in daily life. This knowledge arises from its involvement in discerning and representing patterns, establishing algebraic terminology, and engaging in abstract reasoning (Fitriyani, Widodo & Hendroanto, 2018).

Moreover, the essence of algebraic thinking encompasses a concentration on the interrelationships and patterns inherent to numerical entities, extending beyond the realm of basic arithmetic to encompass the generalization of mathematical operations. It involves the utilization of both mental and formal algebraic models to address mathematical problems effectively (Reinhardtsen, 2020).

Teachers face various challenges when teaching algebra, as noted by (Samuel, Mulenga, & Angel 2016; Sikukumwa 2017). These challenges include learners' background knowledge of algebra, their little knowledge and skills in problem-solving, and inappropriate habits of mind among teachers in enforcing better teaching strategies. Teachers may lack knowledge of the habits of mind needed to come up with better strategies for teaching algebra, and learners may struggle if these strategies are not developed (abid). Consequently, learners may develop negative attitudes toward algebra, affecting their ability to learn the subject (Mazana, Suero Montero & Olifage, 2019). Similarly, in my experience, for the past ten years of teaching algebra, I observed that poor teaching strategies may also lead to a lack of understanding of algebra concepts, which makes learners hate the topic and thus develop negative attitudes toward it.

Innovative and spiral strategies and teaching strategies as habits of mind can be used to change learners' attitudes toward Algebra (Kallick & Zmuda, 2017). Therefore, a growing interest has been in leveraging technology to enhance algebra teaching and learning experiences to address these challenges. literatures have highlighted that integrating technology in teaching and learning activities can significantly improve learners' mathematical capability (Stein, Gurevich & Gorev, 2020). By utilizing dynamic mathematics software packages, such as Kahoot and GeoGebra, teachers can create interactive and engaging learning materials that promote a deeper understanding of abstract algebraic concepts (Szilvia, 2023).

Additionally, technology-based algebra instruction has been shown to enhance students' reasoning skills. By utilizing interactive tools and visual representations, learners can develop logical thinking abilities and apply them to solve complex Algebraic problems using new approaches. These new approaches include simulations, computer gaming environments, adaptive learning, and graphing tools. Based on the above argument, it can be emphasized that technology has become an essential part of education since learners intentionally have become technologically skilled and use it in their everyday lives (Stein, Gurevich & Gorev, 2020;Simuja,2017).

Furthermore, the study by Mart (2019) involved 54 mathematics educators from 15 countries on five continents to determine whether there is a relationship between the self-efficacy of international algebra teachers and their level of incorporating technology in teaching factoring quadratic functions to introductory algebra students. His study revealed a strong positive relationship between teachers' self-efficacy level and their level of technology implementation regardless of country of origin. It recommended incorporating meaningful applications into mathematical methods with real-life contexts, graphs and visualizations, and systematic reviews of background knowledge.

The existing literature proves that technology's effects on mathematics teaching and learning have been acknowledged globally. For instance, Daud, aet al., (2020) conducted a study in Malaysia that collected data from 33 lower-secondary students through pre and post-tests and questionnaires. The aim was to determine the effects of the PhotoMath mobile application on the achievement and attitude of learning algebraic equations for lower secondary school students. The study analyzed data using descriptive statistics and found that applying Photomath enhances the learning of algebraic equations among Form Two students.

### 2.3 Technology integration in mathematics teaching and learning

The integration of technology has gained significant attention in the field of mathematics instruction. According to Falloon (2020), technology integration involves deliberately selecting technologies that enhance specific teaching approaches during teaching and learning. Additionally, scholars concur that successful technology integration should primarily be rooted in curriculum content-related learning processes, supplemented by the effective utilization of educational technologies (Banini–MED, 2018). This study considers Falloon's (2020) definition of technology integration, which further asserts that technology integration goes beyond the mere presence of physical equipment in the classroom; it must also encompass a knowledge base, namely technological pedagogical and content knowledge, which enables productive use of technology.

To facilitate problem-solving and higher-order thinking, research by Bray and Tangney (2017) and Tong et al. (2021) suggests that technology can positively influence students' mathematics performance by fostering these essential skills. Technological tools empower learners and teachers to optimize their time, which was previously spent on monotonous pencil-paper tasks, by redirecting it towards solving complex problems and exploring mathematical concepts in greater depth. For instance, graphing calculators allow students to plot multiple functions quickly, enabling them to analyze the impact of function parameters on graph characteristics, a process that used to be time-consuming. Furthermore, online simulations provide students with opportunities to formulate and test hypotheses, leading to the deduction of mathematical relationships. These advancements demonstrate the transformative potential of technology in promoting active engagement and critical thinking in mathematics classrooms (Drijvers et al., 2016).

Studies have revealed that integrating technology in mathematics teaching can enhance learners' learning outcomes (Berestova et al., 2021; Onyema, Ogechukwu & Anthonia, 2019). Furthermore, technology integration in mathematics supports learner-centered teaching approaches (An & Mindrila, 2020; Hoyles, 2018). Bearing this in mind, the Namibian National Curriculum for Basic Education (2016) recommends a learner-centred approach to teaching and learning. Thus, integrating technology in mathematics education could be a better way to respond to education policy demands. Additionally, Baharin, Kamarudin, and Manaf (2018) argue that ICT integration stimulates learners' interest and curiosity and improves their performance. Therefore, this study assumes that effective technology integration in mathematics lessons could provide guidelines to address the low achievements currently experienced in mathematics. Moreover, the success of this integration heavily relies on teachers' knowledge and ability to plan for integrating technology in the classroom effectively.

Consequently, Koehler and Mishra (2009) and Redmond and Lock (2019) contend that three components, content, pedagogy, and technology, are central to good teaching and must be carefully considered when planning lessons integrating technology in mathematics. The knowledge needed to evaluate these components to integrate technology is known as (TPACK) (Kohler & Mishra 2006). However, the issue of developing this necessary knowledge for integrating technology in mathematics teaching is a critical aspect that needs to be addressed in Namibia. Similarly, researchers suggest that effective technology integration remains a challenge for most mathematics teachers in developing countries (de Koster, Volman, & Kuiper, 2017; Vidal-Hall, Flewitt & Wyse, 2020). These challenges are associated with teachers' technological pedagogical knowledge, confidence beliefs, and access to resources (Kafyulilo, Fisser, & Voogt, 2016; Pettersson, 2021). Furthermore, other studies propose that teachers need to develop knowledge of how to integrate technologies into their classrooms and, conversely, understand how the use of particular technology may affect mathematics teaching (Borba, 2021; Engelbrecht, Llinares, & Borba, 2020;Nepembe & Simuja,2023).

In addition, Harris and Hofer (2011) suggested an approach to scaffolding teachers to integrate technologies into their teaching effectively. The strategy directly links learners' content-related learning needs with particular content-based learning activities and the technologies that best support the lesson delivery. As mathematics teachers decide how to use technology in their teaching, Collins, Brown and Newman (2018) assert that they need to consider content, pedagogy, and the technology they will use to teach. However, the issue of developing the necessary knowledge for integrating technology in mathematics teaching is the most critical aspect to be addressed in this study. Moreover, few studies have involved in-service teachers Alemdag et al. (2020) and pre-service teachers Kafyulilo et al. (2015) in design-based activities for science and mathematics teachers. For instance, Alemdag et al. (2020) found that active participation in collaborative, hands-on activities was crucial in developing teachers' TPACK. In the initial teacher education, lesson design activities have also been found to develop pre-service teachers' TPACK (Kafyulilo et al., 2015; Kim, & Lee, 2018).

### 2.4 Professional Development and Technology Integration

As with any teacher's knowledge, continuous professional development enables teachers to update and build new knowledge and skills to meet the contemporary needs of education. Lander et al., (2022) defined professional development as gaining new skills through continuing education and career training to improve your career. Professional development is more important as far as technology integration is concerned. Despite increasing access to technology (Farjon, Smits & Voogt, 2019 ; Mtebe et al., 2016), mere access and simple use do not lead to effective technology integration in teaching (Farjon et al., 2019). As is the case in many other countries in the world, the Namibian government, through the Ministry of Education Art and Culture (MoEAC), is advocating for technology integration across all subjects; therefore, most schools in Namibia are accorded access to essential technological tools such as computers, laptops, internet, and computer laboratories. However, the skills needed to integrate technological tools into education remain challenging (Hamukwaya, & Haser, 2021). Although teacher education plays a significant role in developing teachers' skills regarding technology integration, some practising teachers are digital immigrants (Torsani 2019). A good number of teachers were trained during the time when the technology for instruction was not well integrated into teacher education by either practice or policy (Chesley & Jordan, 2012; Emre, 2019).

As a result, lack of skills needed to integrate technology affects experienced teachers and novice teachers who may be considered digital natives. Farjon et al. (2019) explained that even new generations of teachers face challenges in facilitating instruction effectively with technology. Kafyulilo and Fisser (2019) contend that even in most initial teacher education, opportunities for training for effective technology integration, such as exposure to collaborative design activities, are limited. As such, CPD plays a vital role in updating technology integration knowledge and enabling digital immigrants to cope with the current demands of transformation in education. According to Gupta and Bhaskar (2020), educators need to develop their technological knowledge through self-motivation or external incentives to foster innovation with technology in instructional practices.

In collaboration with non-governmental organizations, the MoEAC has actively supported schools in promoting access to technological services. Notably, initiatives such as national television and radio services offering paid slots to broadcast educational lessons were offered (Pereira, Sullivan, & Kayari, 2021;Simuja,2024). Additionally, IT companies were engaged to provide internet services and data bundles to teachers, aiming to facilitate and encourage technology integration. These endeavours underscore the dedication of stakeholders within the education system. Furthermore, the MoEAC has partnered with institutions like NAMCOL to provide International Computer Driver's License (ICDL) training. The ICDL is an internationally recognized certification designed to elevate standards of technological competence. In Namibia, ICDL training focuses on certifying users in various modules, including the latest Microsoft Office suites, online essentials, and computer essentials. In 2015, 5,392 teachers underwent ICDL training, with only 300 receiving laptop incentives as recognition for completing the course. By 2018, the number of trained teachers had increased to approximately 1,822 (Ministry of Education, Arts & Culture, 2022;Sepula & Simuja,2024).

However, research conducted in Namibia by Kacelo (2018) and Kanandjebo, (2022) revealed that more than half (53%) of teachers only use computers outside their classrooms for activities such as lesson preparation and professional tasks. Kacelo (2018) recommended that competent ICT literacy trainers should undertake administrative developments, considering the varying ICT skill levels among teachers. Nonetheless, providing teachers with technology knowledge and supporting efficient training is considered important. As Kohler and Mishra (2006) also note, technological knowledge must be related to pedagogical and content knowledge. Hence, to bring about transformative changes in pedagogical paradigms, it is essential to examine how teachers' content knowledge significantly impacts these novel approaches to creative pedagogy. Shulman (1987) asserts that the crucial aspect of differentiating the knowledge base of teaching lies at the intersection of content and pedagogy. Thus, for educators to effectively convert their existing content knowledge into successful pedagogy, Shulman introduces a "Model of Pedagogical Reasoning and Action. Shulman's framework is grounded in the perspective of teachers, who face the challenge of taking their existing understanding and preparing it for instruction" (p.14).

When combined with professional development and exposure to TPACK, as presented by Mishra and Koehler (2006), this reasoning process significantly impacts curriculum decisions and content delivery, as supported by a growing body of research (Baran, & Uygun, 2016; Odajima, 2019). However, Koehler and Mishra, (2016) emphasizes that in order to embrace innovative approaches to technology integration and pedagogy, educators must cultivate pedagogical content knowledge specifically related to technology, which in turn influences lesson planning and decision-making at all educational levels. Mishra and Koehler (2006), who expanded upon Shulman's work, provide a framework that enables educators to construct lesson plans and activities integrating technology within a conceptual framework that encompasses content, pedagogy, and technology domains. This framework is corroborated by Polly (2005), Mishra and Koehler (2006), and their subsequent intersections, highlighting the significance of effective professional development in facilitating the integration of technology in instructional practices.

Professional Development (PD) content should encourage teachers to create lessons and adopt TPACK principles while incorporating technology and enhancing 21st-century learning (Koh, Chai, & Lim, 2017). Wang (2022) suggested that TPACK professional development should involve online discussions, persuasive arguments, summaries, collaborative projects, synthesizing ideas, and providing options for both synchronous and asynchronous learning. Koh (2018; 2019) emphasized the importance of scaffolding through tools like rubrics, a system for evaluating lesson plans, guided practice, and adjusted teaching methods, all of which can boost teachers' confidence in applying TPACK. Lee and Kim (2017) added that scaffolding increases teacher confidence and shifts the focus of teaching from being centred on the teacher to being centred on the student. LATs were initially introduced by Harris, Mishra and Koehler (2009) to enhance the integration of technology in education. Eshelman and Hogue (2023) argued that LATs should encompass activities like creating quizzes, making concept maps, using flashcards, creating Facebook pages, developing websites, digitizing worksheets, and producing e-books. However, the practice of digitizing worksheets and flashcards is a topic of debate among researchers, as it mainly relies on technology for rote learning, which runs counter to the development of 21st-century skills (Chai, Hwee Ling Koh & Teo, 2019; Reister & Rook, 2021). In creating effective TPACK Professional Development (PD), it is crucial to incorporate design heuristics and a simplified instructional design model. Based on their research, Koh and Chai (2016) argued that TPACK should include an additional knowledge component: Design Knowledge (DK). This design knowledge should encompass considerations of context, student characteristics, learning objectives, content, and tasks. Wang (2022) contended that PDs should include a simplified instructional design model because teachers may not possess the skills, training, or practice in the instructional design field.

Koh, Chai and Lim (2017) conducted a study on TPACK-21C interventions, which yielded positive results in various areas, except mathematics. Similarly, Kaplon-Schilis and Lyublinskaya (2019; 2020) explored technology integration with math teachers. Both studies revealed that math educators face challenges regarding confidence and proficiency when incorporating technology. In Koh, Chai, and Lim's (2017) research, interventions encompassing design, self-regulation, collaboration, and reflection had a positive impact on most teachers. The intervention highlighted that having clear pedagogical goals led to improved learning outcomes. Additionally, collaboration, discovery-based learning, and design-focused learning enhanced teachers' confidence in utilizing technology. The researchers also acknowledged that their rubric parameters could have been more explicit, and participants may have lacked some content knowledge. Koh's (2020) study further emphasized the significance of learning by design as a crucial element in developing TPACK skills and effectively integrating technology. Wang (2022) pointed out a noteworthy observation - that there is a deficiency in design elements tailored for teachers to successfully integrate technology within the TPACK framework. When applying TPACK principles to integrate technology, there exists a noticeable gap in lesson designing skills Paquette (2021), which is envisaged to be developed in this study.

### 2.5 Planning algebra lessons that integrate technology

Technology-integrated lesson planning is ordering what learners will learn during the lesson that integrates technology and explains how the learning will be assessed (Schmid, Brianza, & Petko, 2021). In recent years, many governments have encouraged teachers to develop knowledge to plan lessons that integrate technology to foster effective teaching and learning. However, the development of teachers' planning ability for technology-enriched lessons has been argued to revolve around having Technological, Pedagogical, and Content Knowledge understanding (Chai et al., 2019; Koehler & Mishra, 2009; Koh & Chai, 2016; Tondeur et al., 2020). For instance, various strategies have been recommended to assist in developing teachers' lesson panning capabilities (Asensio-Pérez et al., 2017; Chai et al., 2019; Kali, McKenney & Sagy, 2015). Still, researchers have proposed the need for more investigation and interventions to improve teacher learning design capabilities (Nguyen & Bower, 2018; Tondeur et al., 2020).

Scholars argue that the successful implementation of digital technologies across the education curriculum is still significantly lacking. For instance, McFarlane (2019) explains that experts mostly neglect the second matter of looking at their research regarding curriculum adherence. However, merging educational technology research with formal practice in the infusion of information technology in all aspects of the curriculum is bound to bring a qualitative change within the effective delivery of the curriculum in school. Therefore, in this study, it is assumed that teachers may develop knowledge of relating the content, pedagogies, and technologies during the algebra lesson planning process. It is thus empirical that this study focuses on exploring the development of technological pedagogical content knowledge (TPACK) for grade 9 mathematics teachers in the Oshakati education circuit through planning algebra lessons that integrate technology.

### 2.6 Teachers' TPACK Development and learning Activity type (LAT).

Ways to assist in-service teachers' development of TPACK have escalated since it was introduced more than a decade ago (Grotewold, Kohler, & Krimbill, 2022; Koehler, Mishra, Kereluik, Shin & Graham, 2014). Some researchers recommend particular strategies for scaffolding teachers to develop TPACK, such as a collaborative learning-by-design approach (Koehler & Mishra, 2005; Liu, Zhang, Hou, Mian, Wang, Zhang, & Tang, 2021), instructional systems design Angeli and Valanides (2005) and collaborative reflection-upon-practice (Bruner-Timmons, 2018). According to Harris (2016), there are twelve process-based methods of TPACK-related professional learning. These twelve strategies and eight approaches to in-service teachers' TPACK development are abstracted in Table 2.1, with sample references provided for each.

| TPACK Development Approach | TPACK Development Strategy | Description | Sample references |
|---|---|---|---|
| Collaborative instructional design | Learning by design | Educators, content experts, and technology specialists design instruction recursively, often collaboratively | Antonenko (2013); Boschman, McKenney, & Voogt (2015); Koehler & Mishra (2005); Koehler, Mishra & Yahya (2007) |
| PCK-focused approach | Instructional modeling; TPACK-in-practice | Teacher educators model curriculum-based, tech-infused learning experiences for students | Jaipal-Jamani & Figg (2014); Niess (2005) |
| PCK-focused approach | Collaborative lesson study; Peer coaching | Educators plan, observe, critique, and revise each others' teaching collaboratively | Groth, Spickler, Bergner, & Bardzell (2009); Jang (2010); Ndongfack (2015) |
| PCK-focused approach | Collaborative curriculum materials development | Educators co-construct tech-enhanced or –infused curriculum materials for themselves and others to use | Allan, Erickson, Brookhouse & Johnson (2010); Kafyulilo, Fisser, & Voogt (2014); Polly (2011) |
| PCK-focused approach | Technology mapping, game-based learning; deep-play | Educational affordances and constraints of particular devices and software applications are explored and applied to content-specific teaching and learning | Angeli & Valanides (2009; 2013); Duran, Brunvand, Ellsworth & Sendag (2012); Hsu, Liang & Su (2014); Koehler, Mishra, Bouck, DeSchryver, Kereluik, Shin & Wolf (2011) |
| Reflective/ reflexive approach | Teacher inquiry/Action research | Data-based, systematic exploration of teacher-identified focus in teaching and/or learning | Dawson, Cavanaugh, & Ritzhaupt (2013); Pierson & Borthwick (2010) |
| Reflective/ reflexive approach | Case development; learning trajectory | Meta-analytic reflection upon use of technologies in teaching, with a group of educators and/or a researcher | Mouza & Wong (2009); Niess & Gillow-Wiles (2014) |
| Reflective/ reflexive approach | TPACK self-assessment; just-in-time professional development | Periodic self-assessment of extant and desired TPACK levels (all components), used to | Foulger (2015); Roblyer & Doering (2010) |

| | | | |
|---|---|---|---|
| | | direct individualized professional learning | |
| Problem-based approach | Curriculum-based, authentic problem-solving; solving problems of practice | Authentic, contextualized problem-solving using content-related technologies and/or repurposed general- purpose devices and applications | Tee & Lee (2011, 2014) |
| Computer-adaptive approach | Software-based, interactive, formative assessments of TPACK | Interactive, online software assesses teachers' TPACK formatively, as professional learning progresses | Angeli, Valanides, & Mavroudi, Christodoulou, & Georgiou (2014); Doering, Veletsianos, Scharber & Miller (2009) |
| Instructional planning approach | Learning activity types; fidelity-based unit design | Developing TPACK while focusing upon instructional planning of curriculum-based lessons, projects, or units | Bos (2011); Harris & Hofer (2006; 2009); Harris, Hofer, Blanchard, Grandgenett, Schmidt, van Olphen, & Young (2010); Polly (2011); Roblyer & Doering (2013) |
| Workplace learning approach | Community of practice | Teachers' TPACK is shaped by processes of identity development and practice that are contextually and communally affected and held | Phillips (2014); Porras- Hernández & Salinas- Amescua (2013) |

*Table 2.1: Twelve process-based methods of TPACK development, adopted form (Harris & Hoffer, 2016).*

As Table 2.1 illustrates, "TPACK development strategies have proliferated in the ten years since the TPCK/TPACK construct's first appearance in research publications" (Harris 2016, p.12). However, the questions still to be answered in the next decade are: What might the future of TPACK development be? Can patterns be discerned from the first decade of work with experienced teachers? (ibid.). Since the intervention in this study focuses on working with in-service teachers to develop TPACK as they plan algebra lessons that integrate technology, instructional planning is considered significant. Thus, the intervention in this study is designed in line with the LAT proposed by Harris and Hofer (2006; 2009). However, Hofer and Harris (2010) define LATs as taxonomies of content-specific instructional activities with aligned technology that can assist teachers with integrating technology during lesson planning. On the other hand, it is worth noting that the LAT in this study is not used to develop TPACK.

However, the study considered the five basic steps suggested in instructional planning by Hofer and Harris (2009) to design an algebra lesson planning workshop:

1. Choosing learning goals
2. Making pedagogical decisions about the nature of the learning experience
3. Selecting and sequencing appropriate activity types (content) to combine to form the learning experience.
4. Selecting formative and summative assessment strategies that will reveal what and how well learners are learning
5. Select a technological tool and resources that will best help learners benefit from the planned lesson.

Considering these steps is significant during this study because when mathematics teachers are planning technology-integrated lessons for algebra, they may consider the learning goal specific to the algebra topic, which is: "factorize expressions by taking out a common factor and by grouping terms with simple grouping" ([Mathematics syllabus Grades 8 – 9], NIED 2015). They then decide on their teaching method that aligns with the appropriate objective and the assessment method (Pangrazi & Beighle, 2019). As Shavelson and Stern (1981, p.491), as cited by Ritter (2012), "research on instructional planning suggests that teachers balance multiple goals such as maintaining a flow of activity, reducing management problems, teaching concepts and skills, and maintaining a social organization". However, as the emphasis is placed on whether technology can be selected or avoided, teachers' technological pedagogical content knowledge would be developed authentically and as part of the lesson planning process aligned with curricular standards (Harris & Hofer, 2019;Moloi et al.,2023). On the other hand, Harris and Hoffer (2011, p.581) also "developed learning activity Taxonomy, (LAT) specifically for planning mathematics lessons". Wang (2022) suggests that teachers should carefully structure their lesson content to ensure it is easily accessible and flows smoothly. Teachers who plan to integrate technology should provide a concise list of lessons, course content, and their respective locations. Activities should align with TPACK's LATs, encompassing reflective, productive, synchronous, and asynchronous tasks. It is emphasized that instructions for LATs must be clear, with evident learning objectives (ibid).

Although LAT is not central to this study, it should be considered as it relates to curricular decisions and lesson planning within the literature. The LAT suggests a comprehensive, freely available taxonomy of learning activity types and corresponding recommended technologies in nine different curriculum areas (Harris et al., 2010). Moreover, it is acknowledged in this study that LAT can assist teachers in selecting, combining, and sequencing multiple learning activity types based on knowledge of their classroom context, learning needs and preferences, curricular standards, and contextual affordances and constraints (Hofer & Harris, 2016). However, it is worth noting that, in Namibia, the technological advancement and teachers' technological knowledge are still at an embryonic stage compared to the developed countries in which these strategies were explored. Therefore, the recommended educational technologies listed by Harris and Hofer (2011; 2019) for each learning activity in each curriculum area taxonomy may not match the available technological tools in Namibian schools. Nonetheless, teachers can use the LATs approach for instructional planning to address technology integration in a way that fits their context and the emerging technologies available (Harris & Hofer, 2017). Using a full range of digital and non-digital educational technologies that can best afford their teaching and learning, the study assumes that the selected teachers may develop their TPACK, as also witnessed in other studies (Harris & Hofer, 2016; Karchmer-Klein &Konishi, 2021).

The specific activities employed in TPACK development courses vary but often involve the collaborative design of instructional materials, discussions, reflections (Alemdag et al., 2019; Koh & Chai 2014), technology selection, curriculum planning, lesson preparation, and assessment (Ocak & Baran, 2019; Shmbare & Simuja,2022). Many studies have reported that design-based activities are effective in developing teachers' TPACK, with the effectiveness of each activity dependent on its relevance and engagement level (Alemdag et al., 2019; Ocak & Baran, 2019). To support TPACK development among teachers, scaffolding strategies have been proposed, with lesson design playing a central role. Additionally, lesson design activities have played a significant role in enhancing pre-service teachers' TPACK. It is therefore revealed that numerous research studies have been conducted to investigate the development of Technological Pedagogical Content Knowledge (TPACK) among teachers, which employed various approaches as noted by Farjon et al. (2019) and Mouza (2016), with most of the studies conducted with the pre-service teachers. However, documented professional development programs have also targeted practising teachers, aiming to enhance their knowledge and skills in integrating technology.

Limited studies have explored LAT use in pre-service teacher education and in-service teacher professional development. For instance, Figg and Jaipal's (2013) study on the TPACK-in-Practice workshop used LATs during the initial stage of the 4-stage workshop. In this first stage, LATs were modelled for pre-service teachers so that "they can visualize how learners use the tools to achieve a learning goal" (p. 5041-5042). Yet, Karns (2019) investigated the use of the LATs short course as part of a collaborative curriculum design-based professional development experience for teachers and found that teachers' technological pedagogical knowledge (TPK), specialized content knowledge (TCK), and TPACK changed in ways that allowed them to enhance their instruction planning. However, few studies have involved in-service teachers Kafyulilo et al. (2013) and pre-service teachers Kafyulilo et al. (2015) in design-based activities for mathematics teachers and used different approaches. For instance, Mtebe et al. (2015) found that mathematics teachers tended to score less than science teachers, with the majority not completing tasks in learning content using technology. In addition, Harvey and Caro (2017) found that teachers who were guided in lesson design activities through the use of the TPACK framework improved their competencies of teaching with technology than those who were not guided by the framework. At the same time, Alemdag, Cevikbas, and Baran, (2020) found that active participation in collaborative, hands-on activities play a crucial role in developing teachers' TPACK.

Similarly, the study aimed to develop technological pedagogical content knowledge conducted by Lee and Kim (2014) in the United States, which involved participants in lesson design activities with various technologies. This range of technologies may not be relevant to the context of this study, where access to technology and resource challenges are more likely (Njiku et al. 2020). Elbilgin and Sahin (2021) examined the TPACK change of 28 middle school mathematics teachers in Turkey who participated in a professional development program designed to integrate technology into teaching algebra. The findings revealed that the participants' TPACK increased significantly. Although most studies on TPACK development have shown positive results, most were conducted in developed countries. Little can be found in the literature about the development of TPACK among practising mathematics teachers in developing countries. This study contributes to filling the literature gaps on TPACK development in developing countries. Therefore, exploring TPACK development within developing countries like Namibia is of equal significance. While technology integration is a part of the cognitive process teachers regard when planning, a careful exploration of what opportunity is offered to mathematics teachers to develop TPACK when planning algebra lessons that integrate technology should also be considered. Furthermore, this study also intends to reveal how mathematics teachers can be supported to develop technological pedagogical content knowledge. Especially in a developing country context, keeping in mind the suggestion by Hernawati (2019) that addressing challenges related to technology integration requires a contextually sensitive approach.

### 2.7 Theoretical Framework

Theoretical framework grounds the study such that it is borrowed by the researcher from existing research to shape the researcher's inquiry (Mensah et al., 2020). Furthermore, theoretical framework aids in identifying patterns and attributing significance to researchers' observations, thereby positioning the study within an academic context and supporting intellectual discussions (Adom, Agyem, & Hussein, 2018; Lester, 2005; Jaakkola, 2020). An analytical framework is also essential for comprehending specific phenomena within the research, guiding data collection, analysis, and interpretation toward concrete outcomes (Coral & Bokelmann, 2017).

However, the selection and application of a theoretical framework are crucial and contingent upon the disciplinary domain under investigation (Adom, Agyem & Hussein, 2018; Simuja & Silvanus,2023). In this study, the choice of theories was determined by the intention to address objectives pertaining to this study. On the other hand, the researcher is aware that the field of technology integration in teaching is intricate and multifaceted, making it impractical for a single framework to comprehensively encompass all relevant inquiries (Kohler & Mishra, 2006). Therefore, researchers suggest employing multiple theoretical frameworks to gain a refined perspective that informs appropriate methods for data collection and analysis (Adom, Agyem & Hussein, 2018; Chun Tie, Birks & Francis, 2019).

Despite potential limitations, researchers assert the importance of having some framework rather than none at all (Imenda, 2014). Based on the earlier statements, the researcher incorporated two theories and one analytical framework. This study drew concepts from the two theories and one analytical framework that are of equal significance in understanding the development of Technological Pedagogical Content Knowledge (TACK) during the planning of algebra lessons that integrate technology. The two theories are the Sociology of Education by Basil Bernstein (1971), Bloom's Taxonomy Cognitive domain by Benjamin Bloom (1956), and the analytical framework of technological Pedagogical Content Knowledge (T PACK) proposed by Kohler and Mishra (2006). TPACK includes Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK) respectively.

The two theories and one analytical framework complemented each other, such that under Basil Bernstein's theory, the study adopted codes, curriculum, and pedagogy elements to understand mathematics teachers' planning process of algebra lessons that integrate technology. The significance of Bernstein's theory is that it could help in understanding learning in social contexts and the interactions that occur in pedagogic discourse Lysova, Fletcher, and Baroudi (2023), which may be used to create lessons that effectively integrate technology where children are active learners. Studies revealed that pedagogic discourse refers not only to the scientific contents and competencies to be transmitted but also to their transmission and evaluation, which refers to what is transmitted, how it is transmitted and also which student realizations are considered legitimate during planning (Kouvela, Hernandez-Martinez, & Croft, 2018; Nguyen, Leder, & Schruefer, 2021).

Under Bloom's Taxonomy theory, the study focused on the five concepts: remembering, understanding, analyzing, applying, and evaluating. Taxonomy could help assess documents (lesson plans, subject policy, and syllabus) to see how teachers adhere to the taxonomy levels stated in the Namibian Junior Secondary Education assessment policy. Harris et al. (2009) and Hofer et al. (2011) suggested that TPACK could be accessed more effectively through interviews, prepared activities, and lesson plans rather than just using TPACK scales, which only measure teachers' thoughts. Teachers' artefacts may reveal teachers' TPACK development further than what they report.

Moreover, 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 et al., 2012). Koehler and Mishra (2005) advocated for the TPACK framework to address the knowledge necessary for teachers to integrate technology in their classrooms. In this study, TPACK aided in exploring how mathematics teachers were planning their algebra lessons that integrate technology and how such activities potentially offered them the opportunity or not to develop their technological content knowledge. Hence, under TPACK theory, all TPACK constructs were used to understand technological pedagogical content knowledge development. Using two theories and one analytical framework was appropriate as they were not parallel but complementary. This Chapter discusses the two theories and one analytical framework in depth.

### 2.7.1 Bernstein's Sociology of Education Theory.

Bernstein's sociology of education theory focuses on understanding the connections between different social classes (Hordern, 2021;Simuja & Shikesho,2024). Bernstein's theory was therefore adopted in this study to explore the development of mathematics teachers' TPACK through planning algebra lessons that integrate technology in the Oshakati education circuit. Within this theory, the author (researcher) adopted and used three elements of the sociology of education: recontextualization, classification and framing. This study adopted Bernstein's (2000) concept of recontextualizing to explore teachers' abilities in recontextualizing knowledge from the curriculum until it reaches the learners by planning technology-integrated algebra lessons. In addition, recontextualizing is the movement of knowledge from one state to another (Jansson, 2021). In this case, the movement of knowledge is done using technology-integrated lessons. For example, algebra knowledge can be set from a curriculum, translated into the syllabus and mathematics subject policy and converted to practice through planning. Additionally, this can emanate from the curriculum to the syllabus and the textbook. Afterwards, teachers select appropriate pedagogy and technology, pace, and evaluate what they consider relevant to their context. These letter notions are supported by Bernstein (1990), who maintains that within the pedagogic relationship, the teacher wields the power to control the process of acquisition and transmission. Therefore, the teacher sets out clearly defined roles for the learners. “Afterwards, teachers select, pace, and evaluate what they consider relevant for their lessons" (Manditereza, 2019, p.58).

In the Sociology of Education, Bernstein's (1990) critical concepts of classification and framing where visible and invisible pedagogy were pronounced through teacher practices. The idea of classification and framing weaves through the whole study of pedagogical power relations. Classification is concerned with what is considered knowledge of the curriculum and what counts as knowledge in learning. Framing is learners' locus of control over communication rules, where framing can regulate the form of its legitimate message (ibid). In other words, framing refers to the pedagogical relationship between the "teacher and what is taught" (Bernstein 1975, p.88). Although classification is discussed alongside framing, data was interpreted through combinations of framing relations that inform the teacher's pedagogic practice as visible and invisible pedagogy. Bernstein provides an understanding of pedagogy as the agency not merely as reproduction but of interruption: as the space for thinking the 'unthinkable' - the yet-to-be-thought, the possibility of new realities. It was observed in this study that when mathematics teachers were planning algebra lessons, they considered that teaching is also more than just repeating the same teaching method that they know. However, it also transpired that they were pausing and thinking about learners' context and creating an innovative lesson that integrates technology in which lesson objectives could be afforded. Bernstein opined that thinking about teaching is the same as thinking about society and how people interact (Singh, Pini & Glasswell, 2020;Conger et al.,2015). He reminds teachers to ask about how teaching in schools works and how they can improve it. To first make sense of the classification and framing/ planning of knowledge transmission, one needs first to understand the concept of the recontextualization principle. It is imperative to note that before knowledge framing and classification, one must discuss the position of the pedagogic discourse, referred to as the recontextualizing principle (Bernstein 1996; Conger et al.,2016). The content of the syllabus and curriculum is relocated from its original site by the teacher, who, through classification and framing, adopts a pedagogical practice in which technology is integrated that moves knowledge into sites of teaching and learning.

Bernstein (1971, p.83) noted that: "Curriculum defines what counts as valid knowledge whereas pedagogy defines what counts as valid transmission of knowledge, and evaluation defines what counts as a valid realization of the knowledge on the part of the taught." According to Bernstein 1971, pedagogic practices are viewed in two forms: visible/explicit and invisible/implicit, and they are related to the ordering of the teaching curriculum, either sequentially or in parallel, and the pacing of the delivery. Framing relates to the social-class position and assumptions of the families served by the schools. Meanwhile, classification refers to relations between categories regarding the social division of labour and is related to the distribution of power. Additionally, **Visible/ explicit** = strong framing is represented by **F + +** and **F +** while weak framing; **invisible/ implicit** = weak classification and weak framing is represented by code **F - -** and **F-** as explained in Table 2.2**.**

| CODING Schema | F ++ | F+ | F-- | F- |
|---|---|---|---|---|
| Analyzing lessons using Bernstein's concept | Very strong teacher control over knowledge Selection. And very weak learner control over knowledge selection | Moderate teacher influence on knowledge selection | Represent very weak teacher control over knowledge selection and strong learner control over knowledge selection | Indicate that the learner's power or authority was moderate |

*Table 2.2 shows framing codes as adapted from Manditereza, (2019, p.116).*

Table 2.2 represents concepts that were used in analyzing how mathematics teachers describe their lessons that integrate technology in semi-structured interview and journals reflections. Explicit instruction occurs when the teacher clearly explains what needs to be done and how learning will take place. The instructions provided are straightforward and easy to understand, and the students follow these directions (Manditereza, 2019). Additionally, "explicit teaching involves directing learners' attention towards a specific learning objective in a highly structured environment" (Brewin and Statham 2007 p.363). In explicit/ visible framing, the teacher first provides instruction through modelling, explaining to students what needs to be done. Next, the teacher demonstrates the activity and guides the learners through it. In contrast, implicit teaching involves the teacher presenting a problem to the learners without explaining how to solve it. The objective is not explicitly stated. In implicit teaching, learners are encouraged to explore and create their own understanding and mental structures. This approach can be likened to behaviourism, where students develop their frameworks for comprehending rules rather than simply memorizing them. Bernstein (1975) explains that when pedagogy is invisible (weak), the teacher arranges the context in which the learner is expected to rearrange. So, within this context, the learner has more power over what he/she selects, over how he/she structures, and over the time scale, including his/her activities. In this regard, the learners control their own movements and social relationships. The learners seek their knowledge of sources to deepen and enrich their learning capabilities. Classification and framing, therefore, create learning relationships in different learning contexts, Bernstein, (2003) as cited by Wheelahan and Moodie (2021). Since the teacher is a part of the microsystem, his/her pedagogical approach has to consider the type of learner they are dealing with and decide whether it is worth integrating a particular technology or not, as learners may be more interested in the tool itself than what is delivered through it. As in most learning contexts, all interacting factors, like the context and the environment, may either make or break the learner (Manditereza, 2019).

Furthermore, Bernstein's sociology of education theory provides a fundamental lens for understanding the dynamics of educational institutions, especially in terms of curriculum, pedagogy, and evaluation. By incorporating this theoretical basis alongside relevant literature, the study shed light on promoting TPACK development by planning algebra lessons that integrate technology. This is attained through addressing the following research questions: What opportunity is offered to mathematics teachers to develop TPACK when planning algebra lessons that integrate technology? And how can the mathematics teachers be supported to develop TPACK? The researcher preferred analyzing how mathematics teachers describe their algebra lessons that integrate technology using the genres of pedagogy (visible and invisible) to illuminate explicitness and implicitness within the distributive communication rules. Teacher practice tells us how knowledge is selected and distributed and under what context. Bernstein's theory also gave importance to concepts of classification and framing as key concepts in learning; hence, it is emphasized as a theoretical framework. Classification and framing, therefore, create learning relationships in different learning contexts.

Therefore, the researcher scrutinizes the consideration of clear sequencing of their technology integrated lessons in their descriptions. These aspects align with Bernstein's notion of strong framing, where clear learners' activities are considers when technology is planned to be utilized. Nevertheless, it is acknowledged that Bernstein's theory does not explicitly address the levels of learning objectives outlined in the Namibian mathematics lesson assessment policy. As a result, the study supplements Bernstein's theory with Bloom's Taxonomy theory to explore how PACK is cultivated through the planning of integration of technology in education.

### 2.7.2 Boom's Taxonomy Theory

Using Bloom's Taxonomy, the researcher used one of the three hierarchical models: the cognitive domain. Bloom's Taxonomy cognitive domain (Bloom, 1956) is one of Benjamin Bloom's three domains proposed in the 1950s. The original Bloom's taxonomy table consists of six old levels before they were changed from nouns into verbs: knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, 1956; Poh, 2000; Prasad, 2021). Bloom's Taxonomy specifies three hierarchical models for classifying educational learning objectives into six levels of complexity and specificity (Forehand, 2010; Larsen et al., 2022). The theory, known as Bloom's Taxonomy (of educational objectives), hierarchically categorizes thinking skills to represent the learning process. It is a continuum of thinking skills from Lower Order Thinking Skills (LOTS) to Higher Order Thinking Skills (HOTS), with knowledge at the lowest level of the hierarchy and evaluation at the highest level (Alaghbary, 2021). Since planning lessons involves a cognitive decision, adopting this theory may provide a clearer understanding of content level which form one of the domains of TPACK, which its development is being explored in this study.

Although Bloom's Taxonomy was conceived initially to guide the creation and facilitate the exchange of test items, measuring common educational objectives in educational institutions (Krathwohl, 2002; Rodriguez & Albano, 2017), it is deemed fitting for this study where teachers were planning their lessons with assessment activities in which technology is integrated, and this involved their thinking skills. According to Bloom's Taxonomy, one needs to know a concept first and progress through comprehension, application, analysis, and synthesis before evaluating it. Therefore, by adopting this theory, the researcher believes that mathematics teachers only decide to integrate technology that they know and understand and thus plan to progress to application to solve mathematics concepts with such tools. Yet, during the planning workshop, mathematics teachers planned to integrate the technologies they could remember. However, through discussion and comments from others, they could shift their cognitive skills to better understand those tools and progress onto the application level, resulting in a strong framing of their lessons. This means that after the intervention, mathematics teachers could be able to understand and decide better on integrating technologies into their lessons compared to the time before the intervention.

However, in the case of this study, the researcher also observed that although some teachers were able to understand better the use of certain technologies, their planning was restricted to the school and classroom context. Yet this does not limit the use of this theory in this study because this does not mean teachers may not shift into the Taxonomy cognitive levels on the use of technology. Similarly, studies have noted that since its conception, Taxonomy has permeated teaching and instructional planning for almost 50 years, providing a common language for educators worldwide, guiding successful teaching practices, and informing the design of effective instructional material (Alaghbary, 2021; Nyirenda & Simuja, 2023). In

2001, Lorin Anderson, a student of Bloom, and David Krathwohl, a member of Bloom's original team, assembled a group of educators and educational psychologists with the aim of modifying the taxonomy to make it "increasingly and more broadly effective" (Anderson & Krathwohl, 2001, p. 264).

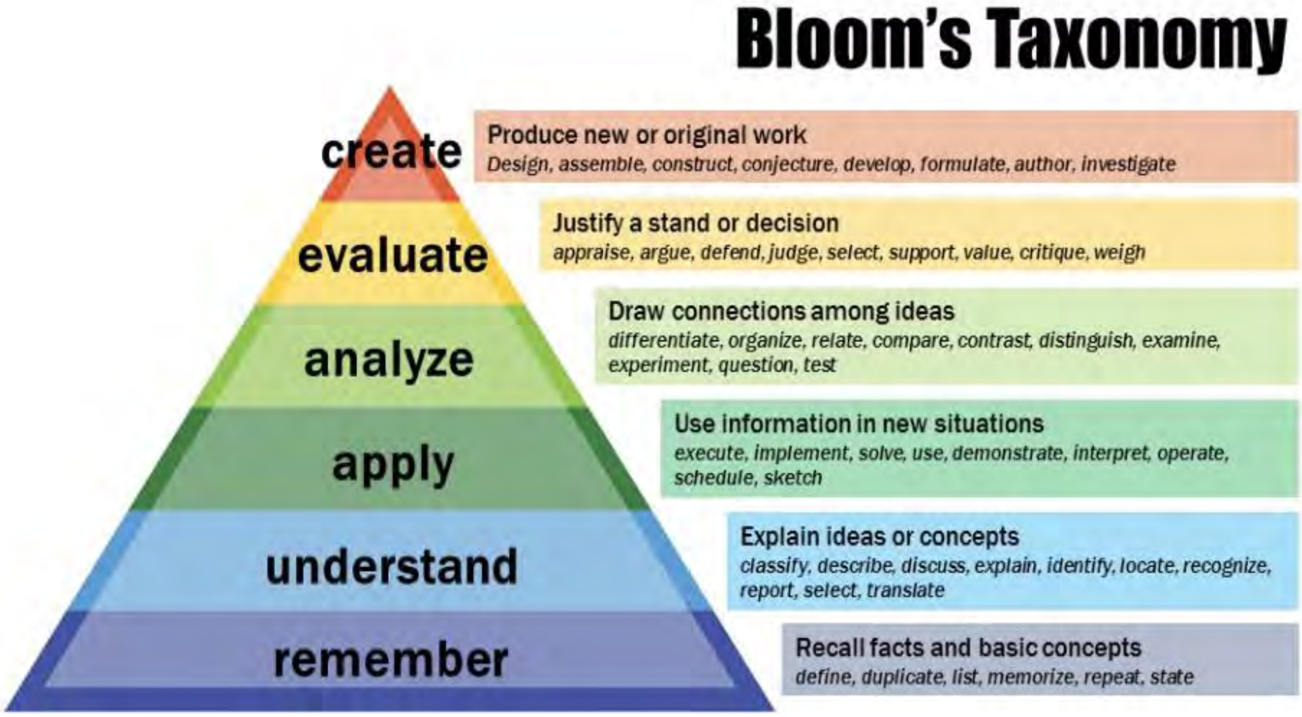


*Figure 2.1: The revised Blooms Taxonomy adopted from (http://cft.vanderbilt.edu/guides-)*

Figure. 2.1 shows the revised Taxonomy by Anderson and Krathwohl (2001), which introduces structural and terminological changes to the original Taxonomy to increase its relevance and accommodate uses other than assessment and contexts other than higher education. The revised Taxonomy in Figure 2.1 provides a common language for educators across the world. It makes it an effective tool that aids in evaluating the content of textbooks for the cognitive processes they engage (Mizbani, Salehi & Tabatabaei, 2020), conducting a content analysis of standardized international language tests (Baghaei, Bagheri & Yamini, 2020), building effective lesson plans (Bümen, 2007), reflecting on classroom practices (Byrd, 2002), informing course design (Prihatin, 2018), creating course-related assignments and projects requiring advanced levels of thinking (Ferguson, 2002), and estimating curriculum alignment, including instruction, materials, objectives and tests (Anderson, 2002).

In addition, the levels of Bloom's taxonomy were used to see how mathematics teachers adhere to the levels of content for algebra expected to be measured in percentages of total competencies in each subject (Febrina et al., 2019; Kennedy, 2006). Bloom's Taxonomy's cognitive domain allowed the researcher to understand teachers' lesson plans and assessment activities and to view deeply how mathematics teachers adhere to the levels of cognitive domains stipulated by the subject policy as they plan the algebra lessons that integrate technology. For instance, the Namibian Grade 9 mathematics, remembering, and understanding cover 20% of the total content competencies requirements (Namibian Mathematics Syllabus, 2016). As the grade 9 algebra, basic competency states that learners should be able to apply index law to simplify expressions. Furthermore, Bloom (1956) noted that, you need to know a concept first and progress through comprehension, application, analysis, and synthesis before you can evaluate it. The application taxonomy level is what learners will be assessed about during their final examination, as indicated in the assessment policy below.

Figure 4 shows the assessment section for grade 9, Namibian Junior Secondary (JS) Mathematics, National Institute for Educational Development (NIED 2023).

The assessment objectives for Mathematics are:

| | | |
|---|---|---|
| **Assessment Objective A**<br><br>**Basic Knowledge and Technical Skills** | Numeracy and algebraic skills | Place value, +, - , *, / , and order of operation, number sense and approximation, operations with fractions and decimals and conversions, percentages, roots and powers, handling algebraic expressions, solving equations, functions |
| | Mental arithmetic skills | Multiplication tables, simple + , - , * ,/ exercises |
| | Measuring skills | Using measuring instruments (i.e. length, mass, capacity, time) estimating, accuracy |
| | Drawing skills | Using drawing instruments, i.e. ruler, compass, protractor, accuracy 1 mm, 1° |
| | Sketching skills(spatial perception) | Recognising and representing key features, i.e. right angles, equi-distance, parallel, proportionality |
| | Maths language skills | Key words (sum, product, ...., more, less, equal, large, small), correct use of symbol notations, conventions |
| | Knowledge of key concepts of Maths in life | Special concepts from money, time and measurements used in real-world problems |
| **Assessment Objective B:**<br><br>**Analysing, Abstraction and Synthesising skills** | Problem analysis skills | Identify relevant and irrelevant elements, recognise the problem |
| | | Analyse real world situations, connect correctly to mathematical concepts and translate into mathematical language |
| | Data analysis skills | Recognise patterns and algebraic relationships, make logical deductions |
| | | Recognise and use spatial relationships in two and three dimensions |
| | Strategy finding skills | Use exploration strategies, like brain-storming, visualisation, exploring examples, testing and identifying steps |
| | Summarising and abstraction skills | Recognise an abstract mathematical rule in series of examples and formulate mathematical concepts in words, diagrams and formula |
| | Combination skills and transfer skills | Combine a variety of appropriate mathematical concepts in solving problems |
| **Assessment Objective C:**<br><br>**Presentation skills** | Formal presentation skills | Write mathematical work in a clear form using appropriate symbols and terminology |
| | Logical presentation skills | Organise information, document steps and present problem solutions clearly |
| | Logical argumentation skills | Judge outcomes of investigations supported by convincing reasons |

*Assessment section for Junior Secondary (JS) Mathematics, NIED, 2023* 5

*Figure 2.2 shows Grade 9 Assessment section as adopted from NIED, 2023*

Although Bernstein's theory may help us to understand pedagogical practice while Bloom's taxonomy helps us to analyze mathematics teachers' lessons based on curriculum content and subject policy, both theories do not optimize the development of technological pedagogical content knowledge, which is being explore by this study. Considering the nature of the intervention in this study, it is therefore against this fact that the survey combines Bernstein and Bloom's Taxonomy with the TPACK framework to explore TPACK development through planning algebra lessons that integrate technology.

### 2.7.3 Technological Pedagogical Content Knowledge

Koehler and Mishra (2006) built on Shulman's (1987) assertion regarding Pedagogical Content Knowledge (PCK) and introduced the conceptual framework of integrating educational technology into pedagogy TPCK or TPACK. This framework adds technology knowledge as a key component of what teachers should know (content knowledge) to integrate technology in teaching (pedagogical knowledge) effectively. For most teachers in the Oshakati education circuit, technology was never part of their pre-service training, and therefore, they find it challenging to integrate technology in mathematics classrooms. However, when they plan to integrate technology into their lesson, their TPACK is assumed to develop (Koehler & Mishra 2009). Technological pedagogical content knowledge is used as the analytical lens in an effort to address the research questions, which aid in analyzing how the teachers' technological knowledge (knowledge of educational technologies) and PCK affect one another as teachers plan algebra lessons that integrate technology (Mishra & Koehler, 2009;Simuja ,2024). In this study, the teachers' planning of lessons was conceptualized around lesson goals, learning activities, and integration of specific technology. Thus, specific technology is considered according to the types of learning activities that have been planned and chosen to match students' learning needs and preferences.

TPACK theory is relevant for this study as the focus of this study is to work with teachers to explore the development of TPACK needed for planning practical algebra lessons that integrate technology. This concurs with Shin (2009), who articulates that what the Technological Pedagogical Content Knowledge (TPACK) means to teachers is considerably important to integrating technology successfully into the teaching process. Additionally, Mishra and Koehler (2009, p.62) emphasized that "there are three main bodies of teachers' knowledge: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK)". The theory also highlights three other interactions: TPK, TCK, and TPCK, as illustrated in Figure 2.3. All these knowledge domains are interlocked to bring along TPACK

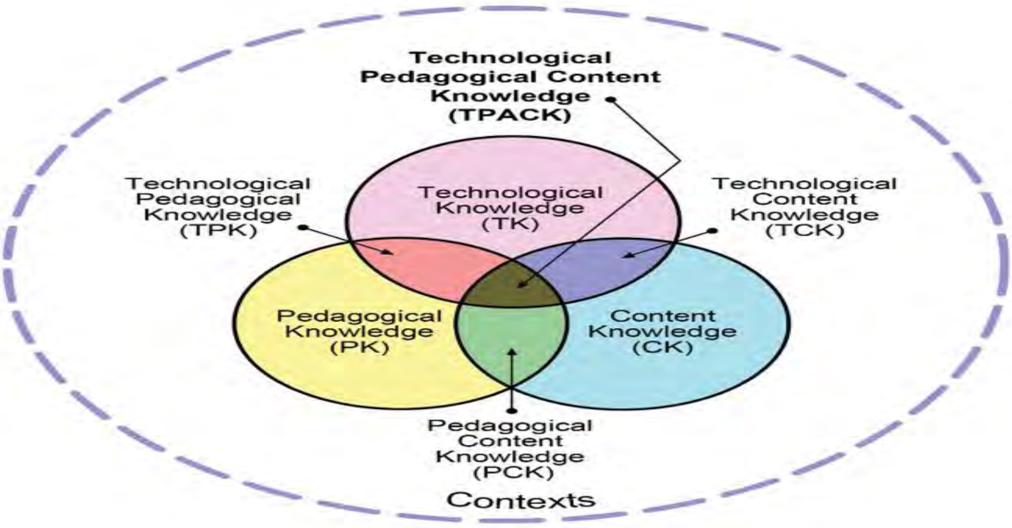


*Figure 2.3: shows the picture of the TPACK framework as adopted from tpack.org*

### 2.7.3.1 Content Knowledge

Content knowledge is the knowledge of the subject matter to be taught by 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 definition is in line with Erdogan and Sahin (2010), who postulate that CK "is the field-specific knowledge" (p.2708). This is important to this study because mathematics teachers must possess the subject knowledge (algebra content) to determine and select the technology to deliver the content to learners. Hence, it was used as a lens to understand the Grade 9 algebra content knowledge of the selected teachers. In the case of algebra grade 9, the content level is application as referred to in Taxonomy levels (Harris, Mishra & Koeher, 2009).

### 2.7.3.2 Pedagogical Knowledge

Pedagogical Knowledge involves how a teacher teaches. Mishra and Koehler (2009) posit that PK refers to teachers' deep knowledge about the processes, practices, or teaching and learning methods. Also, Kartal and Afacan (2016) define PK as the teachers' knowledge of general pedagogical activities, and it incorporates teaching and learning processes, goals and strategies, lesson plans, classroom management, and formative and summative assessment. According to

Koehler et al. (2013), PK also applies to understanding how learners construct knowledge and acquire skills, general classroom management and student assessment. Pedagogical knowledge is necessary for this study because it can aid in assessing whether teachers know how their learners learn best and what teaching strategies, they need to meet their learning needs when a particular technological tool is planned to be integrated when teaching algebra lessons.

#### 2.7.3.3 Technological Knowledge

Technological knowledge refers to the ability to use various technologies, technological tools, and associated resources (Falloon, 2020;Simuja & Silvanus,2023). Also, TK refers to a person's understanding of how to effectively apply technology, such as the internet and software programs, to their daily lives and at work (Koehler and Mishra 2008). These technologies include interactive whiteboards, overhead projectors, routers, computers, tablets and software such as the Internet, Microsoft Excel and Microsoft Word (Koehler & Mishra 2009).

In this study, technological knowledge is crucial for mathematics teachers who are designing lessons incorporating technology. They must be familiar with various technologies including interactive whiteboards, overhead projectors, computers, tablets, as well as software like Microsoft Excel and Word that could be integrated into their lessons to afford effective teaching and learning(Koehler & Mishra, 2009).

#### 2.7.3.4 Pedagogical Content Knowledge

Pedagogical Content Knowledge implies that the teachers should possess the subject knowledge and knowledge on how to teach specific content. According to Harris et al. (2007), PCK refers to teaching knowledge applicable to a particular subject area. Pedagogical Content Knowledge is important in this study because, as mathematics teachers are planning algebra lessons that integrate technology, they need to understand the best strategy for teaching algebra content to their learners.

#### 2.7.3.5 Technological Content Knowledge

Technology Content Knowledge is defined as understanding how the choice of technology affords or constrains the presentation of content in a subject (Koehler & Mishra, 2009). Technological Content Knowledge helps to understand how Grade 9 mathematics teachers describe their planning process for the algebra content that integrates technology and how technology affords the presentation of the planned algebra content. The Namibian mathematics content level for grade 9 algebra is application (Bezuidenhout, 2021). This implies that the content on the technology needs to allow learners to remember, understand and apply what they learn through technology integration (Churches, 2010).

#### 2.7.3.6 Technological Pedagogical Knowledge

Technological Pedagogical Knowledge refers to a knowledge of how teaching and learning change when particular technologies are used in specific ways (Koehler et al., 2013). This component is relevant in this study because it helps to understand how mathematics teachers plan for algebra lessons that integrate technology, how the available technology determines the type of pedagogies, and how the teaching method determines the technology that suits the planned teaching method**.** The technology pedagogical knowledge was used as a lens to aid teachers (participants) during the intervention to carefully consider how specific technologies or technological tools best aid in reaching curricular goals or lesson activities. When mathematics teachers are planning algebra lessons that integrate technology, they may change the teaching strategies after receiving comments from colleagues during the workshop. This may result in them considering explicit/invisible pedagogical discourses and other contextual factors, resulting in a strong framing of their lessons (Bernstein, 2000; Lindahl, Folkesson & Zeidler 2019). Technology pedagogical knowledge may also help in relating how other contextual factors that may be present during the lesson planning process affect the integration of technology in lesson activities.

### 2.7.4 The TAM Model

The Technology Acceptance Model is a framework developed by Davies in 1989, and it is widely used in many studies. This model is based on two ideas: one is called Perceived Ease of Usefulness (PEOU), and the other is called Perceived Usefulness (PU). These ideas are used to predict if people will accept a new technology, as explained by Qingxiong and Liu (2004). This model mainly focuses on how PEOU and PU directly affect whether people choose to use and accept technology.

According to Davis (1989), perceived usefulness means how much someone believes using a specific application or system will improve their work or life. Additionally, perceived ease of usefulness (PEOU) refers to how much a person expects that using a particular technology does not require much effort. This idea matches well with how users see the technology, whether they perceive it as good or adopt it. There exists a promising opportunity to integrate various new technologies into educational settings, aiming to improve the sharing and gaining of knowledge. Users' widespread acceptance of technology has become prevalent, making the TAM a globally appealing tool. Acceptance of technology underscores the crucial role of user acceptance in determining the success or failure of technology implementation. Furthermore, as Mreeza (2017) highlighted, many factors influence an individual's decision to embrace technology. Aspects such as age, gender, cultural background, environmental circumstances, prior experience, and self-confidence play significant roles in the adoption and utilization of technology, as highlighted by Lee, Kozar, and Larsen (2003) as well as Shachak, Kuziemsky, and Carolyn (2019).

Moreover, Mreeza (2017) emphasizes that the primary objective of the TAM is to gauge how external influences affect internal factors like beliefs and attitudes. For instance, the decision of a teacher to incorporate technology into their teaching practices hinges on their perception of whether the specific technology can enhance the teaching and learning process. In simple terms, the features of a potential technology shape how educators view its ease of use and effectiveness.

However, TAM has faced criticism from several researchers and scholars. For instance, Lee, Kozar and Larsen (2003) argue that applying TAM can be challenging. While TAM suggests that technology needs to be valuable and easy to use for adoption, it does not provide specific guidance on what attributes lead to these qualities. These authors propose considering factors such as age, gender, experience, self-efficacy, and the environment to enhance how end-users accept technology. The researcher agrees with Ajibade (2018, pp. 4-9), who explains that TAM benefits personal technology use but isn't designed to address technology adoption in various contexts. TAM appears more effective in explaining why people adopt technology rather than its suitability for educational purposes. This aligns with Shachak, Kuziemsky and Carolyn (2019), who suggest that TAM is overly simplistic, focusing mainly on PEOU and PU rather than studying actual technology use. Neglected and overlooked by TAM are factors like advocacy, building capacity, aligning technology compatibility with its intended use, user support, past technology experience, teamwork, time limitations, and other contextual elements. These factors greatly affect why technology is embraced or rejected but isn't adequately addressed in applying TAM. In the current research, focusing on exploring the development of technological pedagogical content knowledge when planning lessons integrating technology, TAM was not the best theoretical framework. It was deemed unsuitable and excluded due to its limitations that outweigh its benefits.

### 2.7.6 The Substitution, Augmentation, Modification and Redefinition Model

The SAMR model was considered during the initial planning phase of this study. It was developed by Puentedura (2006) to guide the selection, utilization, and evaluation of technology in education (Romrell, Danae Romrell & Kidder, 2018). Substitution, Augmentation, Modification, and Redefinition is a model for describing, categorizing and assessing how teachers integrate technology in their classrooms (Hamilton, Rosenberg & Akcaoglu, 2016). Its primary purpose within the education system is to motivate teachers to enhance the quality of teaching and learning through technology utilization. Hamilton et al. (2016), along with Gorman (2020), elucidate the four levels of the SAMR Model as follows: Substitution: This level involves using technology to replace traditional tools without altering their function, as exemplified by substituting a chalkboard with a PowerPoint presentation. Augmentation: In this stage, technology is a substitute tool to improve the learning experience. For instance, a presentation on the topic of water cycles can be elevated by incorporating a video clip to enhance learner productivity. Modification: At this level, technology allows for task alteration. For instance, a learner may create their own graphics to redesign existing materials, resulting in changes to lesson design and learning outcomes. Redefinition: Technology at this stage enables the creation of entirely new tasks that were previously impossible without its use, such as learners or teachers in Namibia collaborating with peers in other countries to discuss topics like the global impact of climate change.

According to the critical assessment presented by Hamilton, Rosenberg, and Akcaoglu (2016), the primary critique of the SAMR model is that it does not consider the specific circumstances in which it is applied. For instance, it fails to account for factors like the availability of resources, the unique needs of students, and the level of teacher knowledge and support when using technology (ibid.). Different educational settings can significantly influence the outcomes of teaching and learning. Therefore, any model intended for educational purposes should consider the environment in which teachers instruct and students learn.

Furthermore, Hamilton et al. (2016) argues that because the SAMR model does not acknowledge these contextual aspects, it can be challenging to apply it to research in teaching practices effectively. The primary goal of the SAMR model is to classify and match teachers with their stages of technology utilization and their progression on the SAMR scale. The emphasis on integrating technology into teaching and learning diminishes because the primary aim is shifting the degree of technology usage rather than improving the learning methods (Hamilton, Rosenberg& Akcaoglu, 2016). Given the considerations discussed above, SAMR was not deemed suitable for the current study and was consequently excluded as an option.

### 2.7.7 Limitations of the TPACK Framework

While the TPACK framework plays a crucial role in facilitating the effective use of technology in the classroom, it does present challenges and obstacles. These challenges encompass institutional-level barriers, teacher-level barriers, and technology-related barriers (Bingimlas, 2009; Ling, Chai & Tay, 2014), which can impede the advancement toward the attainment of desired learning goals and the barriers are not adequately tackled by the TPACK framework.

School policies and practices do play a pivotal role in determining several key aspects of technology integration in education, including the types of technologies and software accessible to teachers, the allocation of time for integration, the student-teacher ratio, access to technical support, and the financial resources allocated to enhance technology integration into the curriculum. Constraints related to computing resources and technical support can hinder teachers from adopting specific ICT tools, as noted by Eteokleous (2008). For instance, teachers in schools with one-to-one provision of computing devices encounter different design challenges compared to those in schools equipped with computer laboratories. While Mishra and Koehler (2006) stressed the importance of considering various contextual factors related to technology availability and teacher competency across the three primary knowledge domains, limited attention is given to addressing the widening or narrowing of the digital divide across different educational contexts.

Furthermore, teachers' feelings, thoughts, and abilities also affect their readiness to use technology in their classes. According to Mishra and Koehler (2006), effective technology integration relies on how content, technology, and teaching methods work together. These authors suggest that teachers should have different experiences with technology based on the subject they teach. However, the framework doesn't give much consideration to teachers who may lack confidence, have negative feelings about technology, or resist the idea of using new technologies in their classrooms. In other words, when striving to incorporate technology into the curriculum, technological constraints include outdated equipment, a shortage of suitable software, and insufficient technical assistance. These obstacles hinder the effective integration of technology, and the TPACK framework does not thoroughly address these limitations. To mitigate the potential adverse effects of these barriers during the planning phase, it's crucial to enhance teachers' technological proficiency through a well-developed TPACK.

### 2.7.8 Combining Sociology of education, Bloom Taxonomy and TPACK framework

Various studies on the literature review revealed that other researchers used Bernstein's theory for analyzing pedagogy (Cause, 2010; Luckett, 2010; Manditereza, 2019; Naidoo, 2012). Bernstein characterized disciplinary curriculum designs such as science and mathematics as powerful because of their vertical knowledge structures and strong framing of knowledge. For some time, this nature of knowledge argument was used to characterize integrated curricula as a weaker form of curriculum arrangements (Pluim, Nazir & Wallace, 2020). The concepts of strong and weak pedagogic framing fit better with planning lessons than the Socio-cultural theory, which states that society and the interaction within the society are paramount in learning and development (Mitchell, Myles & Marsden, 2013;Shambate et al.,2022). This study explored TPACK development through a planning process that involves cognitive activity; therefore, recontextualizing and visible versus invisible framing, rather than interactions, are paramount to this study. Bernstein (1975, p.119) explains that when pedagogy is invisible, "the teacher arranges the context in which the learner is expected to rearrange". Meanwhile, in visible pedagogy, "the teacher plans a lesson in such a way that it can restrict learners' freedom. The lesson lies within closed boundaries because there is strong teacher-framing and strong teacher classification; even the context is controlled' (Bernstein 1975, p.118). This accounts for strong or weak framing that may affect learners' performance.

This study adopted concepts from the works of Bernstein (1971, 1975, 1977, 1996, 2000 & 2002); hence the study elaborated on converting knowledge to pedagogic communication. Considering various studies on the literature review and the study's research questions, Bernstein's works were significant in exploring how teachers used the recontextualizing rules in transforming curriculum into knowledge. For instance, in actual teaching, a procedure must be followed as the curriculum content is structured so that something must come first; that is, there is a hierarchy of presenting these lessons. The pedagogic discourse and its tools determine what it is that teachers selected as content knowledge, how they transformed content into knowledge, how they sequenced the content, and how they framed the content knowledge. Bernstein (1971, p. 205) made a distinction between what is relayed (the message) and the underlying pedagogic device that structures and organizes the content and distribution (of what is relayed) using the key process of recontextualization. It can be argued that the message is the content to be taught. While, the device could be the technology to be integrated, so teachers may consider the appropriate technology that helps reach lesson objectives by the process of recontextualization.

However, the issues of technology integration and assessment policy also bring some critical limitations to current research using only the sociology of education theory. Although Bernstein's theory is concerned with curriculum/content transferred through recontextualization and framing, Lim, Tan, and Saito (2019), which may involve the use of technology, this theory falls short in describing the teacher knowledge required for effective technology integration in teaching. These knowledge components are articulated in the TPACK framework, and as a result, this study combined the Sociology of education theory and the TPACK framework as suggested by Larsen (2023).

Moreover, the analysis of teachers' lesson planning description requires consider taxonomy levels and cognitive learning domains of cognitive as stipulated by the assessment policy for mathematics (Ministry of Education [MoEAC] 2017). As a result, this study employs Bloom's Taxonomy to analyze how mathematics teachers adhere to the level of cognitive domains required by the algebra subject policy for mathematics grade 9 in Namibia. The taxonomy helps teachers select appropriate technology tools, design engaging learning activities, promote higher-order thinking skills, and assess 'progress (Jaiswal & Al-Hattami, 2020; Churches, 2011). Moreover, it ensures that technology integration is purposefully aligned with learning objectives and enhances content knowledge and pedagogical practices in the context of algebra instruction. Therefore, combining the Sociology of education theory, Cognitive theory, and TPACK framework provided a more holistic understanding of mathematics teachers' technological pedagogical and content knowledge development in their contexts. In the current research, TPACK provided the analytical framework to examine teacher knowledge of technology integration in the classroom. Applying the TPACK framework allowed the researcher to consider all the contextual factors such as the grade, subject, learner's socio-cultural background, types of available technologies, and individual teacher attributes such as their philosophy, teaching style and experience. The conceptual framework for this study is outlined in **Figure 2.4.**

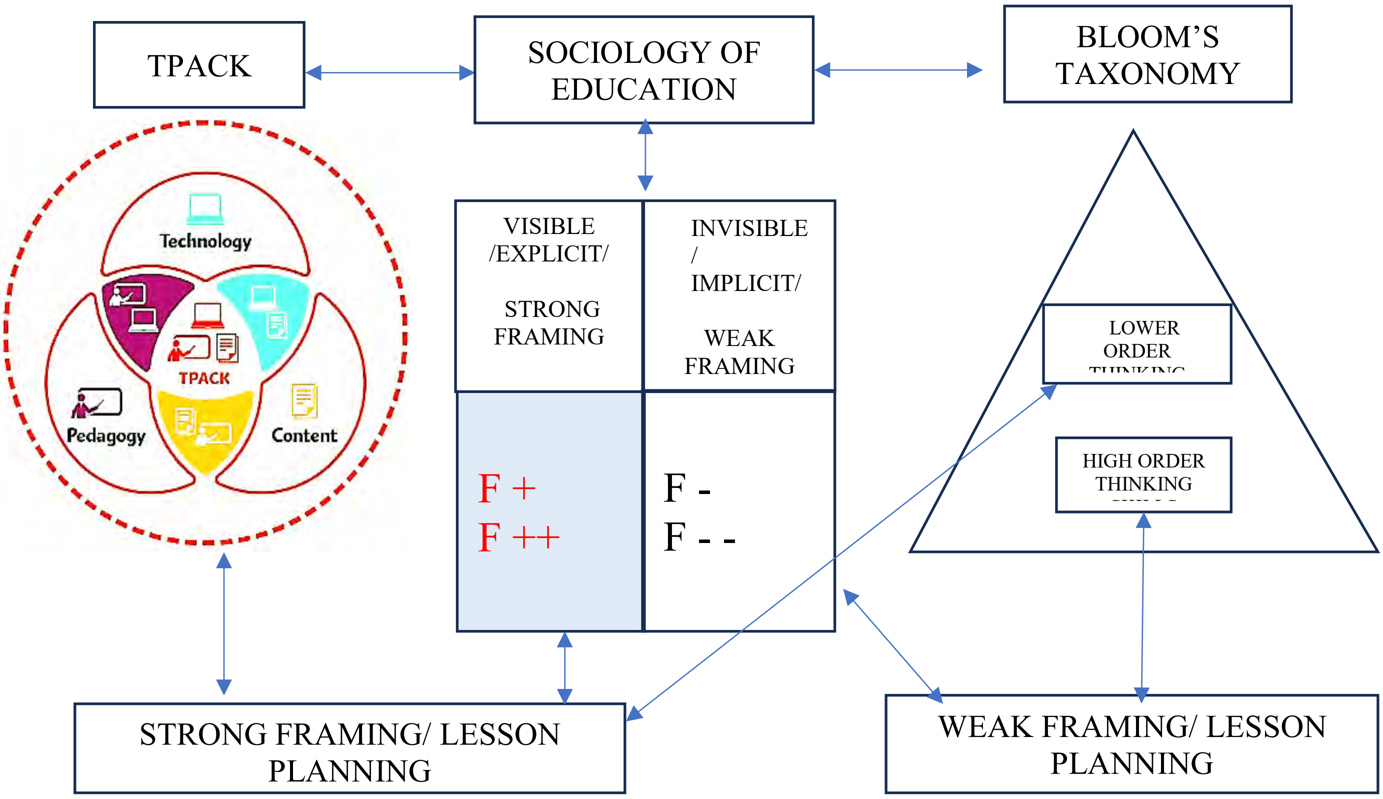


***Figure 2.4:*** *Sociology of education theory, Bloom's Taxonomy theory and TPACK framework combined.*

## 2.8 Summary of the chapter

The literature review commenced by exploring a general overview of the literature concerning algebra teaching and learning and the significance of teaching algebra. Literature indicated that technology integration in mathematics teaching and learning can positively affect teaching and learning. Professional Development and Planning algebra lessons that integrate technology about the development of TPACK through instructional planning were highlighted. It further indicated TPACK development strategies as explored by various studies and highlighted the findings related to the previous studies related to TPACK development. Lastly, two theories and one analytical framework to underpin this study were identified: Bernstein's (1971) Sociology of Education and Bloom's Taxonomy (1956) Cognitive domains, which assisted in the understanding the planning of lessons that integrate technology and TPACK which helped to understand the development of technological pedagogical content knowledge.

# CHAPTER THREE: METHODOLOGY

- 3.1 • Introduction
- 3.2 • Study Designs
- 3.3 • The researcher's position
- 3.4 • Sampling procedures
- 3.5 • Data collection procedures
- 3.6 • Data collection tools
- 3.7 • Data analysis
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- 3.10 • Summary of the chapter

## 3.1 Introduction

This section focuses on the specific approach employed in conducting the study, known as the research methodology. Research methodology entails the particular steps and techniques used to gather, select, process, and analyze information related to the subject (Mishra & Alok, 2022). This section elucidates the rationale behind conducting this research and why the chosen methods were deemed suitable. This section outlines the research methodology applied to address the three research questions posed in this study,

1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology?
2. What opportunities are offered or not to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology?
3. How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge?
4. 

## 3.2 Study Designs

### 3.2.1 Research Philosophy

This study looks closely at a specific case and uses qualitative methods, which means it focuses on understanding the details as participants describe their experience regarding TPACK development rather than numbers. This study applied an interpretive approach, supported by a pragmatic worldview, to explore the development of TPACK through planning algebra lessons that integrate technology in the Oshakati education circuit in Namibia. Interpretiveapproach constitutes the abstract beliefs and principles that shape how a researcher sees the world and how he/she interprets and acts within that world (Kivunja & Kuyini, 2017, p.26). The idea of interpretive was not only borrowed from Saunders et al. (2009) however, it was also suggested by Burrell and Morgan (1979) and Crotty (1980), who stated that there is no single reality; instead, the reality is created by individuals (participants), which is then interpreted.

### 3.2.2 Research paradigm

This study adopted an interpretive research paradigm supported by a pragmatic paradigm. According to Cohen et al. (2007, 2017), an interpretive research paradigm maintains that truths depend on the context of a situation and that there are no absolute truths, as a positivist paradigm argues. Regarding technology integration, the researcher believes that what works best in one context could be interpreted differently in another. Still the researcher moves with similar ideas by, Keisha (2020, p.4-5) "posits that interpretive research seeks to understand phenomena through the meanings that people bring to them."

A research paradigm can thus guide a researcher in conducting a research study and how the data should be interpreted. Furthermore, Patel (2015, p.1) states that a research paradigm is "…the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed." There are various research paradigms. Cohen et al. (2007, p.33) identify the following: "Normative, positivist studies, interpretive, and critical studies." The emerging nature of this study is best suited to an interpretive research paradigm because this research was aimed at uncovering mathematics teachers' experiences and views regarding their TPACK development through planning algebra lessons that integrate technology. As interpretative qualitative research, the focus was on the full complexity of human sense-making in each situation. Considering the idea of Crotty (1998) that, there is no single reality; instead, the reality was created by individuals (participants), which is then interpreted.

Interpretivism's ontological stance is called relativism. The idea of reality is viewed differently by different people (Leedy & Omrod, 2010). Scotland (2012) agrees with this, saying that our senses and consciousness shape how we see the world. Creswell (2014) also believes that interpretivism sees reality as relative. Therefore, in the case if this study, mathematics teacher can plan to integrate technology that they think can help them to achieve the lesson objectives depending on their context. In contrast, others may decide not to integrate technology depending on how they interpret their world. Relativism means that reality is subjective and varies from person to person. In this study's context, these differences depend on the specific situation, the teacher, the child, and the school. These differences can also lead to meaningful actions and interactions based on individual perspectives within that context.

Furthermore, the ontology of interpretive holds that varied realities are constructed by human interactions and meaningful actions. Moreover, ontology further highlights the discovery of how people make sense of their social world in their natural environment through engagement in daily routines, conversations and writings. To sum up the interpretive ontological stance, Crotty (1998, p.43) suggested that "our realities are mediated by our senses, hence without consciousness the world is meaningless". In this study, the researcher believes that the mathematics teachers' lesson planning is realistic in all content subjects and gives access to learning content and pedagogy. However, in this study, the researcher proposes that the decision of planning to integrate technology would depend on how mathematics teachers make meaning of visible and invisible pedagogical discourses with contextualizing knowledge (Bernstein, 1971,1973).

Creswell (2014) conceptualized individual realities as being mediated by our senses. In this study, the framework situates the focus on the relatedness of classroom features in a way in which mathematics teachers consider both the contextual organization of knowledge and its transmission. From an interpretive perspective, the relatedness of classroom features and the participants make up a case to strengthen the current researcher's view that interpretive is relevant to the selected framework. The researcher agrees with Bernstein's (1971) argument that discourse situates learning and interaction in a social context, thereby planning technology-integrated lessons in which the learners are active participants.

Furthermore, this study employed a pragmatic paradigm to support the interpretive paradigm due to the nature of this study as an intervention case study. The pragmatic paradigm is rooted in interrogating and evaluating ideas and beliefs regarding their practical functioning (Kaushik & Walsh, 2019). It is therefore important to use the pragmatic paradigm in this study to reveal a worldview that focuses on "what works" rather than what might be considered absolutely and objectively "true" or "real" (Morgan, 2014, p.5). The researcher is aware that pragmatics asks the researcher to focus on different approaches to inquiry, and its rhetorical nature may be time-consuming. However, the nature of this study suits this paradigm because pragmatism orients itself toward solving practical problems in the real world. It emerged as a method of inquiry for more practical-minded researchers (Creswell & Clark, 2011; Ismail, 2022; Shambate et al.,2022). On the other hand, Creswell (2018) stressed that employing case study methods made it accessible for the researcher to gather data within a specific context. As a result, the researcher used the case study as the research design for this study.

### 3.2.3 A qualitative research design

This study adopted a single case study; a case study is a systematic approach to looking at events, gathering data, analyzing information, and reporting findings to describe the case under investigation as fully as possible (Hancock et al., 2021). Additionally, a case study is a thorough scholarly investigation dealing with a single entity or phenomenon (Fredua-Kwarteng & Ahia, 2015) and allows researchers to comprehend the phenomenon being studied fully. The case study design allowed the researcher to explore a particular issue in depth and from one or more individuals (Cresswell, 2017). This approach enabled the researcher to engage in in-depth discussions and to collect relevant information directly from those experiencing the phenomenon under the study (Saunders & Tosey, 2020; Shambate et al.,2022).

Furthermore, a case study was thus deemed appropriate in this study because the researcher intended to obtain in-depth information as to what ways planning algebra lessons that integrate technology offer or not the mathematics teachers in the Oshakati education circuit an opportunity to develop technological pedagogical content knowledge. It also empowered the researcher to spend a substantial amount of time interacting with the participants and administering the research instruments herself. Therefore, the case in this study was Grade 9 mathematics teachers. The unit of analysis was planning for algebra lessons that integrate technology, mathematics teaching and the development of TPACK.

## 3.3 Researcher's position

In qualitative research, the role of the researcher is crucial because their personal experiences and insights contribute significantly to the investigation and overall comprehension (Palaganas et al., 2017). Positionality refers to the stance or positioning of the researcher about the social and political context of the study, the community, the organization or the participant group (Marvin, 2019). The researcher's position must be carefully considered to prevent any negative impact on data collection and interpretation (Berger, 2015). In this study, I, as the researcher, was responsible for gathering, interpreting, and sharing data. I aimed to capture the perspectives and interests of both individual participants and the group as a whole. Consequently, understanding my position in this study was of utmost importance. During the research, I served on the circuit level's continuous professional development (CPD) committee, specializing in mathematics education. Notably, the researcher and the participants were grade 9 mathematics teachers within the Oshakati education circuit. This positioning likely influenced how participants interacted with me throughout the research process. As a teacher-researcher, I recognized the potential for imbalances in power dynamics between myself and the participants.

Initially, I acknowledged that my roles as a CPD committee member and a mathematics teacher in the Oshakati Education circuit could pose a risk to the study as this may inhibit engagement with the participants as they might perceive that their responses to questions may reveal their lack of lesson planning competencies and may therefore feel pressured to give “correct” answers to please or impress the researcher. To mitigate any power differentials, I worked to establish rapport and trust with the teachers. I made it clear that I was engaging in this research alongside them rather than conducting it on them, in line with the insights of Ngcoza and Southwood (2015). Additionally, I recognized the significance of cultural context in this research. Given that my cultural background aligns with most participants, I understood that I was dealing with beliefs and experiences that were familiar to me. In addition, I needed to put aside any preconceived cultural notions and research assumptions and instead be open to learning from the participants. Moreover, I consistently respected the diverse characteristics of the participants, such as age, language, nationality, customs, race, ethnicity, gender, and marital status, throughout the study. I also participated in a workshop on planning algebra lessons incorporating technology and engaged with the participants. Although I didn't assume the role of a participant researcher in this study, it was crucial to acknowledge how my experiences in the workshop and my position influenced the formulation of questionnaires and adaptation of interview questions. My positionality also played a role in shaping the inferences drawn during the data interpretation process.

## 3.4 Sampling procedures

### 3.4.1 Selection of Site

The study involved ten Grade 9 mathematics teachers selected from four secondary schools within the Oshakati education circuit in Namibia. The four schools were selected based on analyzing the grade 9 mathematics results for the end of the academic year 2022. It was noted that all four secondary schools had exhibited below-average performance in Grade 9 mathematics during that period. Aspers and Corte (2021) advocated for establishing defined boundaries in a case study, emphasizing the need to delineate specific aspects of the case(s) that can be feasibly examined within the constraints of time and resources. These defined boundaries should directly align with the research questions and likely encompass illustrative examples of the subject of inquiry. As elucidated in Section 1.4 of Chapter 1, this interventionist study aimed to explore the development of technological pedagogical content knowledge of Grade 9 mathematics teachers. This was achieved through designing algebra lessons integrating technology, with the ultimate aim of improving TPACK development to effectively integrate technology and improve mathematics performance.

### 3.4.2 Selection of Participants

Mathematics teachers in this study, possessed diverse experiences in incorporating educational technologies into their teaching practices and varying levels of proficiency in technological pedagogical content knowledge. Martinez-Mesa et al. (2016) and Cohen et al. (2007) proposed four important factors that researchers should consider concerning sampling:

- the size of the sample;
- representativeness and parameters of the chosen sample;
- access the researcher has to the sample and
- the strategy used for sampling.

The selection of participants in this study considered these factors, too. Therefore, participants were selected through the application of a purposive sampling technique, as described by Pandey and Pandey (2021) and Patton (2014). This method is employed by researchers to engage with individuals who possess specialized knowledge on particular subjects, as articulated by Cohen et al. (2018). This approach enables the researcher to leverage the unique attributes of participants, ensuring an optimal contribution to addressing the research inquiries.

While initially intending to collaborate with eight mathematics teachers, the study attracted considerable interest from qualified individuals who met the criteria. Consequently, the research deliberately selected ten participants. Given that qualitative research sample sizes can range from 4 to 35 (Malterud et al., 2016; Shambate et al.,2022), the researcher deemed a sample size of 10 to be appropriate, affording a comprehensive and detailed exploration of each case (Patton, 2014). The inclusion of ten mathematics teachers was crucial to secure the availability of reliable and high-quality data, even in the event that some participants opted to withdraw voluntarily from the study. In this study, participant selection was predicated on criteria established by the researcher.

Therefore, to be eligible for participation in this study, teachers were required to meet the following criteria:
(a) Possession of qualifications and teaching grade 9 mathematics.
(b) Accumulation of five years or more of teaching experience.
(c) Availability of access to educational technologies within their school.
(e) Attended some ICT training at the Oshakati education circuit office.
It can be reasoned that the participants who adhered to this criterion could be able to plan algebra lessons that integrate technology as they may possess technological knowledge at some point since they attended ICT training conducted by the Oshakati Education Circuit Office. They are qualified mathematics teachers and thus deemed information-rich to provide insight into what opportunities are offered to develop their TPACK when planning algebra lessons that integrate technology. The purposive sample in this study included mathematics teachers from three different schools with different numbers of years of teaching experience, gender, and age. Patton (2015) suggested that the maximum variation (heterogeneity) in the purposive sample is a strategy that aims at capturing and describing the central themes that cut across a great deal of variation.

### 3.5 Data Collection Procedure

The way a researcher conducts their study and the questions they aim to answer should determine the methods they use to collect data (McMillan & Schumacher, 2014). According to Saunders et al. (2009), when using a case study design, it is important to gather information from different sources to verify the data. This process, known as triangulation, involves using various ways to collect information. One advantage of using a qualitative approach is that it allows for a deep understanding of the participants' personal experiences and the specific situations where a phenomenon occurs (Alase, 2017; Hanson et al., 2011). In this study, the findings were confirmed and made more credible by gathering information from different sources (Abdalla et al., 2018; Shambate et al.,2022).

Before the study began, each participant received research information consent letter, explaining the purpose of the study and request for their consent. This information also clearly outlined the procedures for protecting their information, ensuring their anonymity, and providing a way to opt out if they wished. No money or other incentives were given for participating in the study. While participating in the study may have benefited the participants' professional growth, they also had the option to decline if they chose. However, most of them requested to continue attending the workshops on planning their lessons even after the study ends because they wish to improve their professional development. In addition, the researcher collected data from March to June 2023. Physical copies of demographic open-ended questionnaires, reflective journals, and analyzed documents were kept in a secure location at home. Audio recordings were transcribed by professionals and then stored safely. The researcher planned to keep them for the next six months.

In addition, Data were collected sequentially, first the demographic open-ended questionnaires were self-administered before the study, to gain the mathematics teachers' perceptions on planning algebra lessons that integrate technology before then workshop. The study involved three workshop discussions to introduce the educational technologies, TPACK constructs, and mathematics teachers' training on planning algebra lessons that integrate technology. Mathematics teachers and the researcher (me) wrote journal reflections after every workshop and other research activities. Semi-structured and focus group interviews were conducted after the workshop to gain insight into mathematic teachers' TPACK development and how they could be supported to develop TPACK. Mathematics teachers were asked to provide three lesson plans within four weeks after the third workshop. Various data-gathering techniques were used to enhance data credibility through triangulation methods. I then discuss the tools below as they would be utilized in the research process.

## 3.6 Data Collection Tools

### 3.6.1 Demographic Open-ended Questionnaires

The researcher hand-delivered the self-developed questionnaires to the ten participants in person during the mathematics refresher workshop that took place early in February 2023. Rapport was established with both the participants of the study and their supervisors prior to commencing the research. Building a strong foundation of trust and open communication was essential for fostering collaboration and ensuring the success of the study. This gave the researcher a chance to explain the purpose and value of answering all questions. The participants (respondents) were requested to answer all the questions.

All participants were expected to send back the demographic open-ended questionnaires a week after receiving the questionnaire and before this study's workshops. However, only eight out of ten returned the questionnaires before the workshops, and the other two participants requested that the second copy be sent via email, stating that they had misplaced the first copy. As a result, two questionnaires were mailed and they were brought back on the day of the first workshop. In this case, it can be reasoned that the researcher witnessed one of the drawbacks enunciated by Cohen et al. (2011) and Bertram and Christiansen (2017) that mailed questionnaires are not quickly returned by participant.

The demographic open-ended questionnaire consisted of three sections. Section A elicited about personal information such as gender and working experience, section B requested data about the availability of resources and use, and Section C consisted of a table that asked mathematics teachers to describe their technology-integrated lessons before the workshops. In a table with a Likert-type scale, mathematics teachers were asked to rate themselves regarding their perceived technical skills on planning lessons that integrate technology and to describe their technology integration competencies before the workshops. After the table, there is a comment section in which mathematics teachers further describe their planning of algebra lessons that integrate technology. The demographic questionnaire was applied before the first workshop to discern individuals' perceptions of their competencies in technology integration and their ability to plan lessons that integrate technology. Additionally, this revealed mathematics teachers' prior knowledge before the intervention and the support needed during the intervention. The questions for section three were designed using the ideas of Mishra and Koehler (2006), Harris and Hoffer (2009) and Blooms (1956). This data was to respond to the first research question **(See Appendix D)**. Data from the Questionnaire was also valuable for the researcher's workshop evaluation.

Additionally, the researcher was aware that some participants may not fill out and return the questionnaire (Napolitano et al., 2018). Some respondents may hastily answer the questions and may not even finish be answering all the questions, especially if the questionnaire is too long (Chirumamilla et al., 2020; Shambate et al.,2022). In this study, these challenges were not experienced because the demographic open-ended questionnaires were not developed for too long but still captured all the important themes. The demographic open-ended questionnaire was then piloted on two mathematics teachers who were not part of the sample and were from other schools outside the research site, and minor modifications were made to the questions. This helped minimize ambiguity in questions and test the relevance of questions in answering the research questions (Bertram & Christiansen, 2020).

### 3.6.2 Workshop

The workshop presentations were key to this study. A workshop is vital in this study because it assisted for mathematics teachers to develop knowledge through recontextualization of knowledge. Bernstein's view (2002, p.31) is that "knowledge that is reproduced in curriculum undergoes another process of recontextualization". He defined the recontextualizing principle as one 'which selectively appropriated, relocates, refocuses, and relates other discourses to constitute its own order and orderings' (Bernstein, 1990, p.184). "The recontextualizing rules regulate not only selection, sequence, pace, and relations with other subjects but also the theory of instruction from which the transmission rules are derived" (Bernstein, 1990, p.185).

Morais (2004) employed Bernstein's concept of pedagogic discourse to define learning in social contexts and the interactions that occur in them that may be used to create contexts where learners are active learners. The teacher-learner relationship and visibility of pedagogy in these pedagogic contexts are examined by examining how knowledge is structured and communicated. It creates a learning environment because participants can engage and participate in the activities (Sedláček & Sedova, 2017; Shambate et al.,2022). More so, the workshop was planned in this study to offer learning of research activities through social recontextualization, so that participants would be afforded an opportunity to develop their own interpretations, challenge their initial understanding and grow as critical thinkers. The study conducted three workshops. In the first workshop, mathematic teachers shared their views and technological knowledge regarding the educational technologies that could be integrated into algebra lessons.

All ten mathematics teachers, one ICT expert and one mathematics expert (subject advisor teacher) were invited to attend the face-to-face workshop. The first workshop took place on Friday, April 2023, after school hours at one school. During the workshop, mathematics teachers sensitized each other about the possible technologies that can be integrated into mathematics lessons. It is worth noting that the mathematic teachers may possess technological knowledge at some point because they attended the digital skills training offered by the

Ministry of Education Art and culture through the Oshakati Education Circuit. After introducing the constructs of TPACK and the training on planning algebra lessons that integrate technology, mathematics teachers demonstrated their lesson planning in groups, which were discussed for necessary improvements.

The second and third workshops took place online over Zoom technology and served to give additional development support to mathematics teachers. In these workshops, mathematics teachers designed individual algebra lesson plans considering their own context and their lessons were discussed and commented on for necessary improvements. Unstructured discussions and note-taking were ideal during all three workshops since, as Bertram and Christiansen (2015, p. 84) describe, “one does not have to follow through a checklist, ticking off boxes or rating expected activities as they happened, but rather, one uses field notes to write free descriptions of what is happening.” Participants were asked to write three lesson plans each after the workshop for document analysis. The data generated during the first, second and third workshops informed answers to first, second and third research questions.

### 3.6.3 Journal reflection and field notes

Journal writing was done to enable the researcher and participants to interpret their individual actions through reflection on personal experiences of research activities and shifts in the construct of TPACK. According to Zulfikar and Mujiburrahman (2018), reflective journals have a dual purpose of capturing and tracking teachers’ experiences as well as reflecting on their learning and accomplishments. The researcher and teachers reflected after every workshop based on their feelings, insights, and experiences on developing TPACK through the planning of the Grade 9 algebra mathematics lesson plans. Reflection was used as the data source for this study to record changes reflect on accomplishments and respond to all research questions. Also, the journal guide (**see Appendix E**) assisted the participants and the researcher in reflectively recalling their involvement in the study throughout the study. Although Journals might be a good source of information, the limitation is that the information may not be enough because some teachers might choose not to write journal entries due to time constraints and procrastination. In essence, reflective journaling aided the researcher in bridging the gap between what the Grade 9 mathematics teachers do, know and believed as far as the planning of algebra lessons that integrate technology is concerned. It also aided them in falling back on their experiences, opportunities, fears and expectations regarding the phenomenon under consideration.

Additionally, mathematics teachers reflected on the workshop activities and the lessons that they planned after the workshops. The researcher took field notes throughout all the study's activities with the teachers, i.e., during interviews and workshop discussions. According to Bergen and Labonté (2020), taking field notes enhances the data from the observations and interviews and brings more light to the events. In the case of observations, field notes not only record "what is seen and heard but also capture events that would have occurred (Chiumento, Rahman, Machin, & Frith, 2018; Shambate et al.,2022). The researcher, therefore, took notes of any ideas that were of interest and had the potential to make sense of the data. The data from field notes was also useful in the researcher's evaluation of the research instruments.

### 3.6.4 Semi-Structured Interviews

Semi-structured interviews were used in this study to gather data on personal perspectives and beliefs (Aspers & Corte, 2021). Semi-structured interviews are conducted orally and recorded by the researcher or someone who is trained to do so (Mouton, 2013). With a semi-structured interview, the interviewer and interviewee are partners, even though the interviewer asked the questions (Marcia & Vicki, 2020). For interviews to be an effective data collection method, knowledge is socially co-constructed by the interviewer and participant (Brinkmann & Kvale, 2015; Johnson & Rowlands, 2012; Rapley, 2012; Roulston, 2014), although the influence each has over the process varies.

Pandey and Pandey (2015) claim that qualitative interviews are structured, semi-structured or unstructured. The researchers must not impose their preconceived notions because if they do, the result will be biased. This helps in controlling issues of bias. Researchers sometimes give away too much such that participants begin sharing their preconceived notions. On that note, Best and Kahn (2016) warn that interview data can easily be biased and misleading; hence, it is imperative for researchers to guard against providing too much information that makes the participant "fake" their response.

During the interview, the intent of the study was continually highlighted, and the participants were advised that all information would be kept confidential and anonymous. Moreover, participants were discouraged from using or stating any information that may lead to exposure, e.g., mention of names, schools or people and sought their consent to redact names should a slip-up occur. All interviews were conducted in English, as it is the main language of official communication at these schools. Bailey (2008, p.129) postulates that "translation adds an additional layer of interpretation as words or phrases may be directly translated" and so lose their meaning or nuance. For fairness, reliability of the research findings, and not to disadvantage a participant whose home language falls outside of the researcher's capabilities, the decision was thus made to conduct the interviews in a language the participants and the researcher are familiar with and as previously mentioned, is the official communication language of this school.

Semi-structured interviewing was appropriate for this study due to the nature of the research topic (Promoting grade 9 mathematic teachers' TPACK development through planning Algebraic lessons that integrate technology in Namibia.) which necessitates gathering data that also allows the selected participants to share their experience on what opportunity is offered or not to develop pedagogical content knowledge (Research Question 2) as well as their insights on how they can be supported to develop TPACK (Research Question 3). According to Cohen et al. (2011) and Johnson and Rowlands (2012), semi-structured interviews are the most effective methods to collect data on personal perspectives, attitudes and experiences, which cannot be collected as effectively by other methods such as direct observation (Patton, 2015).

The semi-structured interviews were conducted after conducting the three workshops and after mathematics teachers had submitted their lesson plans. The interviews were conducted over three weeks, as participants agreed to be interviewed on different days depending on their convenient time schedule. The interview schedule was emailed to all participants the day before the arranged interview to ensure fairness. All participants agreed to participate in face-to-face interviews that took place at their schools. The interviews lasted between 25 and 45 minutes, depending on the participants' shared views. Before the interview, the researcher discussed informed consent, including, among others, confidentiality, anonymity, voluntary participation, the option to withdraw at any point and detailed information on the university's approval of this study. At this point, the researcher also requested permission to record the conversation for transcription, that an account of the interview would be provided to verify accuracy, and that notes would be taken.

Semi-structured interviews with well-formulated guiding questions derived from the idea of Mishra & Koehler (2006), Harris & Hoffer (2009) and Blooms (1956) were well-suited to capture these intersubjective views. The interview session allowed the researcher to decide what she needed to hear from participants while creating a conversation among participants around the topic and posing prompt questions. This allowed the researcher to summarize what she learned from the participants. The researcher introduced the issues that were discussed and kept participants focused on the topic (Creswell 2013; Newman 2011).

To ensure alignment of the interview protocols and guide (**see Appendix F)** with the study's theoretical frameworks, the interview questions were formulated from the dimensions of the TPACK tenets to access and understand the selected ten mathematics teachers' technological pedagogical and content knowledge development. An interview guide was used to direct the flow of questions. All the interviews with each teacher were audio-recorded and later transcribed to allow member checking and respondent validation. The notes were also taken as a backup in case of equipment failure where the voice recorder was permitted and as an additional backup to the interview. These were all in an attempt to ensure the credibility of the finding.

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. From the pilot study experience, it emerged that the quality of the data obtained from an interview is very much dependent upon the skill of the researcher and the openness of the participants to reveal themselves. It appeared to the researcher that, at times, the participants felt under pressure to say what they thought the researcher wanted to hear. However, most of the answers were revealed and validated through triangulation with other data sources, as they mostly had similar questions in different formats. Data collected from semi-structured interviews was used to answer all research questions.

### 3.6.5 Focus group interviews

The focus group interviews (**See Appendix F**) were conducted with eight participants to get a collective view within a social context through interactive discussions (Shearer et al., 2020). A focus group can be defined broadly as a type of group discussion about a topic under the guidance of a trained group moderator' (Stewart 2018: p. 68). When opting for focus group interviews, the researcher was aware of the following strengths and weaknesses of focus group interviews, as indicated in Table 3.1.

| STRENGTH | WEAKNESSES |
| --- | --- |

| | |
|---|---|
| • The researcher develops a high level of analysis across groups<br>• The researcher becomes immersed in the data<br>• It is a creative process<br>• It reveals a high level of understanding<br>• It produces rich data | • It is a complex process<br>• It is time-consuming<br>• There is a large volume of data<br>• There is the potential for researcher bias<br>• Analysis may move beyond the focus of the research question<br>• May misinterpret consensus |

*Table 3.1: Strengths and weaknesses of focus group interviews*

Although the researcher noted some weaknesses of focus group interviews such as withholding of ideas and modification of responses, the strengths of focus group interviews outweigh the weaknesses, yet the data from the focus group was validated with individual interview data and document analysis. Additionally, the researcher was aware that loss of confidentiality and anonymity can erode trust between researchers and participants, potentially deterring individuals from participating in future research studies (Crane, 2020). However, in this study, participants used their own pseudonyms for anonymity throughout the study.

The study conducted one focus group with eight mathematics teachers after conducting face-to-face semi-structured interviews, although the study initially conducted a workshop with ten mathematics teachers. Two participants requested to be excluded from the focus group interview with a reason that they were conducting the exam at that period. Some participants complained about transport, therefore, the option remained to conduct focus group interviews via Zoom, following the request from participants. The date and the time were agreed upon, and a convenient schedule for the participants. The participants were requested to consent to the recording of the focus group interviews. The participants were informed that there were no wrong or right answers. Each one was free to give his/her own point of view. The focus-group interviews consisted of five questions about mathematics teachers' TPACK development insight, planning of lessons that integrate technology, and how mathematics teachers can be supported to develop TPACK. The reason for involving focus group interviews is to create a space that would allow participants to share their views and learn about experiences encountered by others. As a researcher, my role in the focus group interviews was to initiate interview questions and tape-record the responses. Data that emerged from the focus group interviews assisted in responding to all research questions (RQ1, 2, 3).

### 3.6.6 Document Analysis

Documents such as lesson plans designed by the participants, Curriculum, syllabus and Assessment Policy were analyzed by the researcher using a document analysis guide (**see Appendix G**) to analyze and understand teachers' planning of algebra instructions that integrate technology and reveal the development of technological content knowledge, respectively. A document guide was derived from a scoring rubric developed by Harris and Hofer (2012), which provided an analysis of the mathematics teachers' TPACK as it aligns with their intention in planning lessons that integrate technology. However, using outdated or irrelevant documents will be avoided.

## 3.7 Data analysis

According to Friese (2019), data analysis is categorized into different stages: editing, coding, and creating an electronic data file. For this study, the researcher attempted to derive meaning from the data using techniques that complement the case study. As data was generated, the researcher read and re-read the data sources, particularly the questionnaires, journal reflection, field notes and interview transcripts, as these provided the most detailed descriptions, as emphasized by Demetriou et al. (2017). The data were checked in terms of correctness, consistency, and legibility. After it had been edited, it was coded, and symbols were assigned to raw data. This study quantitatively analyzed the data collected from the demographic open-ended questionnaires using descriptive statistics. Descriptive statistics transforms or summarizes a data set into either a visual overview, such as a table or graph or a single or a few numbers that summarize the data (Bertram & Christiansen, 2014).

The researcher used thematic analysis to analyze the data from journal reflection, field notes and interviews, which is "the process of identifying patterns or themes within qualitative data" Maguire and Delahunt (2017, p. 3352). Inductive analysis approach ensured that the themes emerged from the collected data (Cresswell, 2018). The findings were more narratives, descriptions, analyses, statements, and words than figures, quantities, and numbers. Hence, the thematic data analysis model allowed the researcher to immerse herself in the data, interpret that data, deduce conclusions and make recommendations from the data in relation to the main study objectives (ibid.). The researcher also used a computer software program, namely Atlas. ti, in order to accommodate multiple possible overlapping coding of data (Manguire & Delahunt, 2017). The researcher used components of the TPACK framework adopted from

Mishra and Koehler (2006) to analyze data gathered from journals' reflections, documents, and interviews. All the components of TPACK, as adapted from Mishra and Koehler (2006), served as a lens for analyzing specific knowledge elements of technological pedagogical and content knowledge developed (or not) by the selected Grade 9 mathematic teachers.

The lesson plans were analyzed using the TPACK evaluation tool, Technology Integration Rubric (TIR) developed by Harris et al. (2012), see **Appendix G**. Furthermore, the taxonomy levels offered a lens to analyze documents (lesson plans) using Bloom's taxonomy theory to indicate if teachers developed TPACK or not by reviewing how taxonomy/ content matched with a selected technology. The recontextualization, framing and classification from Bernstein's theory were used to scrutinize data from focus group interviews, interviews and journal reflections. The analysis focused on mathematics teachers' technological pedagogical and content knowledge development through planning algebra lessons integrating technology. Finally, the researcher used different colour highlighters to group the data, then moved from coding to categories, sub-themes, and themes and coded the data, that is, the process of choosing labels and assigning them to different parts of the data (Engler et al., 2021). (see table 3.2).

| **Tools** | Questionnaires | Journal reflection | Semi-Structured Interviews | Focus groups | Document analysis | *Field notes* |
|---|---|---|---|---|---|---|
| **Code** | $Q_1$ | $R_1$…$R_2$. $R_3$ | $SI_1$ … $SI_2$…$SI_3$ | $FG_1$...$F_2$... $FG_3$ | $DA_1$ $DA_2$ | $FN_1$...$F_2$...$F_3$ |

*Table 3.2: Relevant information (biographical data) about the participants.*

Sifting was applied to filter information from interviews and questionnaires, considering Cohen et al. (2018, p.462) posit that "early analysis reduces the problem of data overload by selecting out the significant features for future focus". However, data from journal reflection and field notes were reported as they were.

### 3.8 Trustworthiness

Trustworthiness in qualitative research, encompassing credibility, transferability, dependability, and confirmability, is essential for ensuring the integrity and reliability of research findings. Credibility hinges on transparency in the research process and employs techniques like member checking and triangulation to enhance trust in the findings (Creswell & Miller, 2000; Lincoln & Guba, 1985; Riazi, Rezvani, & Ghanbar, 2023). Transferability was facilitated by providing detailed descriptions of the research context and methods, enabling readers to assess the applicability of findings to their own contexts (Patton, 2002; Tuval-Mashiach, 2021). Dependability was maintained through clear procedures and audit trails, ensuring consistency and transparency in data collection and analysis (idid). Confirmability was achieved by minimizing researcher bias and grounding interpretations in participants' perspectives, bolstering the objectivity and neutrality of the research (Lincoln & Guba, 1985; Hong, & Cross Francis, 2020). Adherence to these principles not only upholds the integrity of qualitative research but also enhances its credibility, applicability, reliability, and objectivity, ultimately contributing to the advancement of knowledge in the field.

### 3.8.1 Credibility

Credibility refers to establishing that qualitative research outcomes are credible or true from the perspective of the participants in the research (Closa, 2021). In this study, the researcher used strategies that Lincoln and Guba (1985) and Cresswell (2007) recommended to ensure the findings were reliable. One of these strategies is triangulation, which means using different methods to collect data. The researcher in this study used techniques like workshop discussions, field notes, semi-structured questionnaires, semi-structured interviews, document analysis, focus group interviews, and journal reflections to get answers to the research questions.

Another strategy used to ensure credibility was member checking. This means the researcher showed the participants the transcribed data from the interviews, the study's findings, interpretations, and conclusions. This way, there could be an agreement between the participants and the researcher on what the study found. Also, this study's credibility was strengthened by carefully following all the steps in the research process. Since the study used thematic analysis for the written data, the findings were presented using the participants' exact words.

### 3.8.2 Dependability

Dependability refers to the data's consistency over time and across study conditions (Polit & Beck, 2020). To demonstrate dependability, the researcher had another peer in the same profession read and react to participant transcripts with their embedded researcher interpretations; this helped the researcher confirm an unspoken reality. Because the analysis was conducted by a peer, it gave the researcher insider analysis and feedback before the study was made public.

### 3.8.3 Conformability

Conformability means how much others can agree with or support the results of a study (Closa, 2021). During the in-person interviews, the researcher made sure to treat the participant with respect. This way included maintaining a certain distance to show respect for their personal space. The researcher also asked permission to use a tape recorder for all the interviews. Additionally, the transcripts of the interviews were sent to the participants for them to check and confirm (Brooks, te Riele & Maguire, 2014). In this study, conformability was ensured by using the exact words of the participants and by keeping careful records of all the decisions and analyses.

### 3.8.4 Transferability

Boadu (2021) explains that transferability in qualitative research means how much we can apply the findings to different situations or places. It's about whether what we learned in one study can be useful in other situations, according to Kesavan (2021). In this thesis, transferability isn't about having a sample that perfectly represents everyone; instead, it's about "helping readers figure out if the same ideas will work in their own situations", as noted by O'Kane et al. (2021, p.77). The idea of transferability, or how much the findings can be helpful in other places, is different from other parts of research because it's up to the readers to decide how relevant the findings are to their own situations (Polit & Beck, 2020). Since this study focused on specific schools in the Oshana Region, the findings can't be applied to other places because the circumstances may differ.

## 3.9 Ethical considerations

Ethical considerations in research encompass a range of principles and guidelines aimed at ensuring that research is conducted with integrity, respect for participants' rights, and adherence to professional standards (Smith, 2018). In the case of this study the researchers ensured that participants were fully informed about the purpose, procedures, risks, and benefits of the study before they agree to participate, maintaining confidentiality and anonymity of personal information collected (Johnson & Williams, 2020). Participants were not coerced or unduly influenced to take part in the study, and they were given the freedom to withdraw from the research at any time without facing consequences (Jones et al., 2019). The researcher took precautions to minimize the risk of physical or psychological harm to participants, obtaining ethical approval from the director of education, Oshana region and implementing procedures to mitigate potential risks (Brown, 2017). The researcher tried to maximize the benefits of the research while minimizing any potential harm (Smith, 2018), respecting participants' autonomy and treating all participants fairly and equitably, regardless of their characteristics or background (Davis & Lee, 2021). By adhering to these ethical considerations, researchers can conduct their studies in a manner that respects the rights and well-being of participants and upholds the integrity of the research process (Johnson & Williams, 2020).These ethical principles emphasize the importance of doing what's right (beneficence) and avoiding harm (non-malfeasance). In this study, the researcher obtained informed consent from participants, minimized potential harm, safeguard their privacy and confidentiality, refrain from using deceptive practices, and grant them right to withdraw from the research (Heck, 2014). Some of the ethical considerations applied by the researcher are described below

### 3.9.1 Informed consent and Voluntary participation

All participants in this study participated voluntarily. No force, coercion, or bribery was used to get participants to participate in this study. Those who refused to take part in the study were not penalized in any way. The researcher advised participants that they had a right to decline to answer questions or to withdraw consent from participation at any time throughout the study (Wiles, 2012). The researcher asked for permission before proceeding with conducting the workshop and collecting data. The researcher informed the participants of the activities of the study and those allowed the participants to make their own decisions and participate voluntarily. Written consent was sought from all participants after the researcher had explained the purpose of the study before the study.

### 3.9.2 Privacy and Confidentiality

Legend and Ormrod (2016) emphasize the protection of participants' identities as the clearest concern in protecting their interests and well-being in research. On that note, the researcher observed confidentiality at all times by protecting the identity of all the participants. The collected data were filed and kept safe where access cannot be reached. The interview did not contain the names of the participants.

### 3.9.3 Permission to carry out a study

A formal request to carry out the study was made to the relevant authorities from the Oshana Region Educational Directorate (ORED) before any visitation and before any data were collected see **Appendix B.** the Oshana Region Educational Directorate the Oshana Region Educational Directorate.

## 3.10 Summary of the Chapter

This Chapter informed readers of methodological components such as the research design, population, sampling, research instruments, data collection procedures and ethical considerations. It also delved into the data analysis procedures, the justification for the steps followed, and aspects of reliability, validity, and transferability. A process of data collection and analysis was provided, which highlighted how codes were generated and themes discovered. These themes form the basis of the empirical findings, which will be discussed in Chapter 4. The steps taken to ensure trustworthiness were outlined by stressing the importance of methodological triangulation and member checks. The researcher's position as a complete insider was stated, and the steps taken to counter subjectivity and bias were verification and reliability checks. In conclusion, ethical considerations were discussed by indicating how ethical clearance was obtained and the participants' well-being, confidentiality, and anonymity were ensured. Subsequent of this chapter is Chapter 4 which is the presentation of the data gathered through the data gathering techniques as discussed in this chapter. The data is presented according to the research questions.

# CHAPTER FOUR: EMPIRICAL RESEARCH FINDINGS AND ANALYSIS

- 4.1 • Introduction
- 4.2 • Mathematics teachers' demographic information
- 4.3 • Mathematics teachers describing their process in planning algebra lessons that integrate technology
- 4.4 • Oportunites offered or not to develop mathematics teachers' TPACK
- 4.5 • How can mathematics teachers be supported to develop TPACK
- 4.6 • Summary of the chapter

## 4.1 Introduction

This chapter presents the findings on exploring development of TPACK through planning algebra lessons that integrate technology in the Oshakati education circuit, Namibia. The chapter comprises the views of mathematics teachers that were collected from the semi-structured interview, focus group interview, notes taken during the workshop, journal reflection and an open-ended demographic questionnaire. The data presented in this chapter was gathered in different phases, as discussed below:

**Phase 1**. Demographic open-ended questionnaires were administered to ten mathematics teachers (see Section 3.5.1) before the workshop.  The aim was to lay the foundation of this study by gaining insights into the mathematics teachers' perceptions and attitudes on the use of technology for teaching and learning before conducting the study. For further details regarding this data collection approach, please refer to the section for an in-depth exploration of the methodologies employed.

**Phase 2**: In this phase, the researcher thoroughly examined the collected questionnaires and proceeded to lay the foundation for the support needed during the workshop. As a result, three workshops were conducted with the selected ten Grade 9 mathematics teachers.

**Phase 3**: After the workshops, mathematics teachers were requested to design and plan three algebra lesson plans and learning activities that integrate technology in relation to their own teaching contexts. Documents (lesson plans, curriculum and assessment policy) were used for triangulation by the researcher to analyze and understand teachers' planning of instructions that integrate technology and reveal the development of technological pedagogical content knowledge, respectively

**Phase 4**: Semi-structured interviews, one focus group interview and journal reflection were undertaken after the workshops were completed.

**Phase 5**: The collected data was analyzed and interpreted. Then, the findings were presented to the participants for member checking.

- In order to establish the development of TPACK through planning algebra lessons that integrate technology in the Oshakati education circuit, ten mathematics teachers were subjected to questions during the interview sessions, journal reflection and workshop discussions. The demographic open-ended questionnaires' responses obtained are shown in tables, detailed descriptions and direct quotations as presented in this chapter. Based on various categories in this chapter, themes identified in the research data are presented in various sections. The chapter is divided into five sections: (4.1) Introduction, (4.2) Mathematics teachers' demographic information, (4.3) mathematics teachers describing their process in planning algebra lessons that integrate technology (4.4) Opportunities offered or not to develop TPACK, and (4.5) How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge (4.6) Summary of the chapter.

The primary objective of this study was to explore the development of TPACK through planning algebra lessons that integrate technology. The utilization of diverse data types allowed for a triangulation approach, enhancing the robustness of the findings. This triangulation method was employed to comprehensively and holistically address all the research inquiries within the study. All mathematics teachers' quotes from journal reflection are presented as transcribed, i.e., even if there are language issues, such as grammar, codeswitching, and repetition of words in their responses, it is kept as it is so that the responses would not lose their meaning and for sense-making and meaning, codeswitched words are indicated in the brackets after every codeswitch. Where references were made to institutions and individuals, their names were withheld to ensure anonymity. Likewise, to ensure the research participants' anonymity, the interview transcripts are represented by a letter with numbers instead of their actual names.

The findings were organized according to the three research questions that guided the process.

1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology in the Oshakati education circuit?
2. What opportunities are offered or not to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology in the Oshakati education circuit?
3. How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology?

This chapter started with findings based on the biographical information on the demographic open-ended questionnaire, which was captured on an Excel spreadsheet before it could be analyzed. The rest of the findings from the questionnaire and other sources were structured according to the research questions that were asked in chapter two.

### 4.2 Mathematics teachers' demographic information

The first and second sections of the demographic open-ended questionnaires were posed to mathematics teachers to fill in information such as gender, teaching experience, teaching level, training attended, and qualification. The aim was to solicit the effect of the above-mentioned demographic characteristics on the participants' responses from mathematics teachers.

| **Total number of participants** | **Age group** | **Gender** | | **Subject taught** | **Range of teaching experience** |
| --- | --- | --- | --- | --- | --- |
| 10 | 28-43 | **Female** | **Male** | Mathematics grade 9 | 7-24 |
| | | 6 | 4 | | |

*Table 4.1 shows the participants' demographic information*

Ten mathematics teachers from four different schools took part in this study, four participants were male, and six were female. All participants were mathematic teachers teaching grade 9. Each teacher had taught for five years or more. However, the issue of gender, age and qualification were found to affect TPACK development because some mathematics teachers indicated that they have not been in the teaching profession for some times. Similarly, Sastria (2023) examined the influence of gender, age, and qualifications on the TPACK levels among

211 biology teachers. His results in ANOVA showed no significant effects of gender and age on the levels of TPACK.

### 4.3. Research Question 1: In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology?

To answer the research question one, relevant data from demographic open-ended questionnaires, workshops, journal reflections, and interviews were collated and analyzed. Mathematics teachers were asked to describe their lesson planning that integrated technology before and after the workshop. The aim for mathematics teachers representing their lessons that integrate technology before the workshop was not only to contribute to a deeper understanding of how they intend to integrate technology but also to assist in a better understanding of how mathematic teachers perceive the integration of technology in mathematics lessons before the workshop. It could also reveal whether mathematics teachers can plan lessons integrating technology and weigh how much support is needed during the workshop. According to Bergdahl and Nouri, (2021), knowing various technologies applicable to teaching and learning situations is necessary. Therefore, when planning lessons that integrate technology, mathematics teachers may be familiar with utilizing some essential technologies.

The following themes emerged from the data collected to address question one. These themes were based on the relative frequency with which they occurred in the margin notes of each tool.

1. Teachers' Technology Access and Use
2. The significance of technology use
3. Teachers' Self-Reported Technical Skills

#### 4.3.1. Teachers' Technology Access and Use

Sub-themes immersed under this central theme include the internet, access to technology and technology use. Mathematics teachers were asked in the demographic open-ended questionnaires to indicate how many hours a day they use different technologies for personal and professional purposes. Figure 4.1 below shows the results.

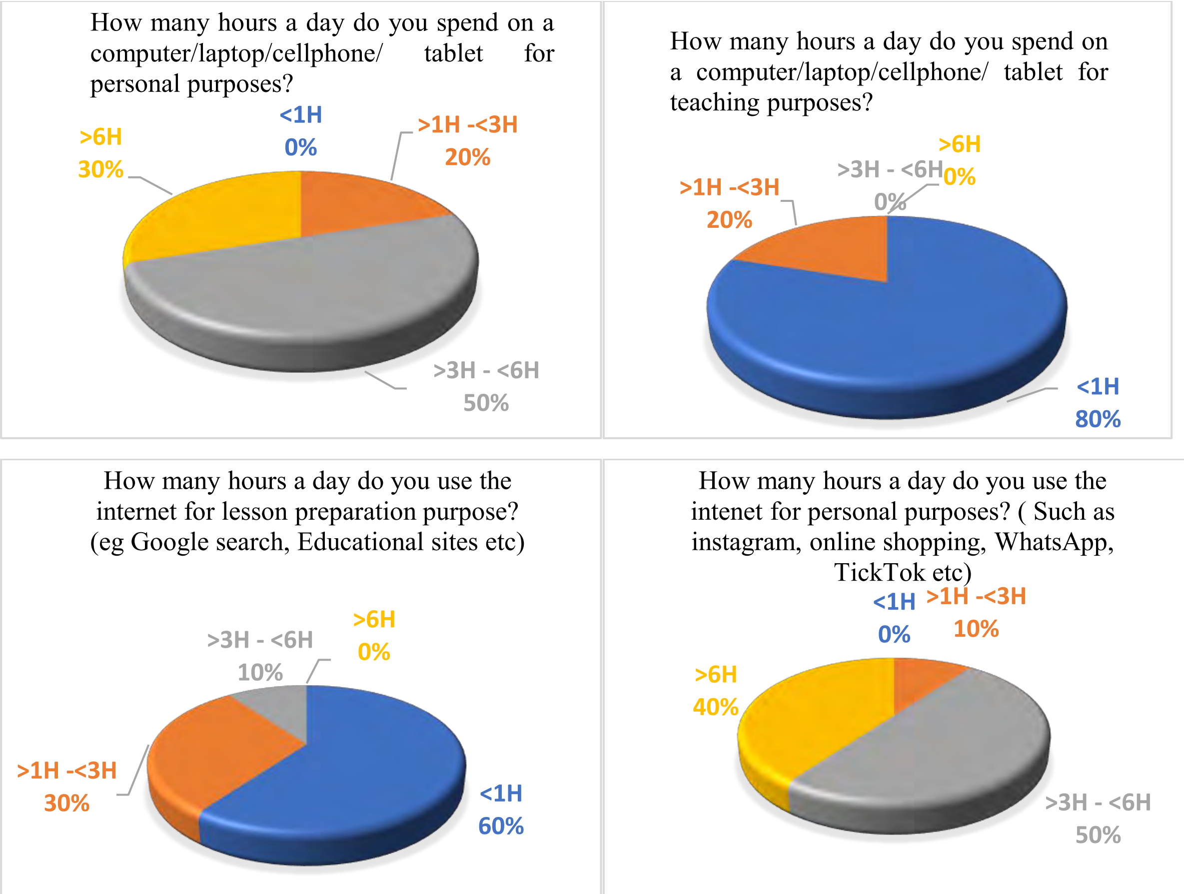


*Figure 4.1 shows mathematics teachers' technology access and use (n = 10)*

It can be deduced from Figure 4.1 that all teachers used technologies per day. However, most respondents (n = 5, 50%) spend over three hours daily on a computer, laptop, tablet, or cell-mobile phone for personal purposes. Regarding using computers, laptops, tablets, or mobile cell phones for teaching purposes, most teachers (n = 8, 80. %) only spend less than an hour. In contrast, another (n=2, 20. %) spent two to three hours per day, with no mathematics teacher spending over four hours teaching. This result indicates lower technology use for teaching compared to personal purposes. In addition, it can be further deduced from Figure 4.1 that mathematics teachers use the Internet daily. The findings further indicate that when using the Internet, most teachers (n = 6, 60%) reported spending less than one hour per day on lesson preparation. While only one teacher indicated spending more than three hours on lesson preparation. This finding implies that most teachers are not using the internet for lesson preparation. Furthermore, there was a wide range of responses regarding internet use for personal purposes, with four teachers (n = 4, 40%) reporting that they spend over six hours per day and (n=5, 50%) spend more than three hours to less than six hours a day on the internet for personal purpose. It can also be seen that respondents spend more time on the internet for personal use than for educational purposes. However, the collected data revealed that although some schools are well equipped with computer laboratories and Internet access provided for the benefit of all learners and teachers, they are not being utilized. This is confirmed by a statement from a questionnaire comment section respondent, T9-Q stated that “the computer laboratory is available however, it is less functional because their software programs are outdated, which makes their operation too slow.”

Similarly, T3-Q commented:

> *“I consider our school so lucky because we were one of the schools where the government provided a computer lab and internet. However, these computers have no updated software programs or educational apps suitable for teaching mathematics. Only some teachers use them for ICT lessons.”*

Overall, it can be deduced from Figure 4.1 that mathematics teachers have access to technology, and there was higher usage of the technologies by teachers for personal compared to teaching purposes. Nonetheless, these findings imply that all the participants spend less time integrating technology for teaching than for personal purposes. The following sub-section investigates the significance of technology use and how teachers use technologies in their classrooms.

### 4.3.2 Significance for Technology Use

The sub-themes emerging under this main theme are creating real-life learning experiences and sources of information, fostering inclusive learning, and promoting learning engagement and motivation. Mathematics teachers described how they perceived the importance of technology integration in their lessons in demographic open-ended questionnaires before the intervention and after through semi-structured interviews and journal reflection. It was essential to find out form the individual participants about their ways and purposes of technology integration before the workshop for several reasons: Firstly, teachers are the ones who actively implement technology in their classrooms. Secondly, mathematics teachers can reveal their ability in technology lesson planning and ability for integration before the workshop as this research sought to tap into their first-hand experiences of the workshop impact that could affect the way they plan using technology. Thirdly, after the workshop, teachers may have an in-depth understanding of how to effectively incorporate technology content and pedagogy into their contexts and classroom dynamics, considering the criticism from the workshop discussions. Lastly, they could describe how they intend to integrate technology based on their context.

Therefore, by sharing their experiences of technology use and reflecting on their planning of lessons that integrate technology after the workshop could reveal their TPACK developments, this data aimed to answer the first research question: How do mathematics teachers describe their lessons that integrate technology?

#### *4.3.2.1 Source of information*

Before the workshop and after planning lessons that integrate technology, mathematics teachers were asked to describe the ways in which they plan to utilize technology. The findings revealed that teachers use different technology tools to access various resources, from the internet, YouTube videos, e-books, teachers' guides, and games. The teachers reported using these materials for various aspects of teaching and learning, including lesson planning, teaching, assessment, and analyzing learners' performance.

> '*I use online resources and websites to supplement my lessons. This includes educational videos, articles, and interactive websites that provide additional information or allow learners to explore scientific concepts independently. (T3-Q)*
>
> *I find technology to be extremely helpful in my teaching. It greatly aids me in preparing and delivering a resourceful lesson. I rely on technology to access valuable resources and teaching materials from the internet and other schools. In my classroom, I frequently use YouTube videos and PowerPoint presentations. Additionally, I develop worksheets and assess learner work by downloading them online.* (T6-SI)

Some mathematics teachers indicated that they are unsure about what to consider when planning technology-integrated lessons. Therefore, this makes it difficult to determine the technology that is suitable for the content that they have to teach. However, they find it easy to operate a particular technology. This was revealed by T1-Q, who stated:

> *There are some topics that I find it hard to get an appropriate technology to integrate in mathematics. However, as for the personal uses, I always find a way for the technology relevant appropriate use". T7-Q also Commented, "I guess I have little knowledge on various technology that I can integrate into mathematics lessons for some topics, I always find it easy to uses, for instance, flashcards as a teaching aid in algebra lesson than technologies, which is time-consuming."*

In contrast, T5 Q had this to say:

> *By using the internet, I can access various teaching resources such as math activities, YouTube videos, and online quizzes that I can use in my class. However, with online quizzes ,strict monitoring is needed to ensure learners use the technology for their interests rather than subject matters.*

Additionally, T2-Q stated,

> *"I use tools like Google Forms or Microsoft Forms to create surveys for my learners. I use these forms for pre-assessment, feedback collection, or understanding my learners' prior knowledge on a particular topic."*

Regarding the teachers' use of technology as an information source, the above findings provided valuable insights into the technology used to access internet resources, such as math apps, Quizzes, and YouTube videos. These digital materials are used across various aspects of the teaching and learning process, from lesson planning, lesson delivery, assessment, and performance analysis. Furthermore, this study revealed that after participating in the workshop on planning lessons that integrate technology, mathematics teachers consider utilizing these tools more than just delivering the content but delivering the right content that addresses the lesson objective. This is evident in T6-RJ's comment that:

> "*During lesson planning, I experienced a situation where the technology I planned to use, for instance, a YouTube video I downloaded, had either a high level or low level of algebra subject content. Therefore, planning to integrate such video may result in failing to achieve the right objective for my lesson*

In the same vein, T7-RJ proclaimed:

> *"I opted to use Kahoot because it allows me to create the lesson activities for what I want to teach rather than YouTube videos that are set by someone else with content that may not address my lesson objectives. I, therefore, make sure that the Kahoot that I plan to use consists of the right content and that my assessment would address the right level of taxonomy to enhance performance".*

When prompted to elaborate more, T7 further added that:

> *For example, the objective for the lesson that I planned was factoring algebra expression. This required learners to apply the algebra rule in order to factorize.*

*Therefore, I ensured that the content in my video or Kahoot was about the knowledge level of taxonomy and application level*.

It is evident that before participating in the lesson planning workshop, mathematics teacher had a positive attitude towards using technology for information sources in their lessons. Still, some reported that they are sometimes unsure when and where to integrate technology into their lessons. However, after participating in the lesson planning workshop, they improved their perception of using technology as a source of information such that they consider effective utilization of these tools for achieving their lesson objectives to improve lesson outcomes.

#### *4.3.2.2 Offers engaging lessons for learners*

The findings from semi-structured interviews revealed that certain teachers utilize technology to offer engaging lessons to their learners. This includes interactive presentations, educational videos, and virtual simulations that bring abstract concepts to life. Online collaborative platforms enable real-time interaction, fostering learners' engagement through discussions and group activities. Additionally, gamified learning apps and interactive quizzes make learning more enjoyable, motivating learners to participate actively. Technology also allows for personalized learning experiences, catering to individual needs and pacing, ultimately enhancing overall lesson engagement.

In this regard, T5 went as far as to elaborate that his primary use of technology also involves presenting complex lessons. He further highlighted that technology supports him in diversifying his teaching methodologies, which motivates her learners' engagement. She explained as follows:

*I use technology to make my lesson interesting to my learners by incorporating various teaching strategies and transitioning from a teacher-centred to a learner-centred learning environment, which I find to motivate my learners. (T5-SI)*

Similarly, T9 emphasized the necessity of technology in enhancing learners' lesson engagement. She expressed that technology enables the learners to be practically involved in the lesson activities. She explained as follows:

*"I believe teaching with technology helps meet learners' learners learning needs and introduces them to practical learning. Technology offers great potential for exploring new areas beyond traditional teaching methods." (T9-FGI)*

T2-RJ described her lesson after participating in the workshop as follows:

*"I plan algebra lessons that integrate technology by first identifying specific learning objectives. I then select appropriate digital tools or software that align with these objectives. I plan to use GeoGebra during lesson presentations; this could promote lesson engagement and understanding of algebraic concepts."*

Similarly, T1-RJ explained,

*"The lesson I plan typically includes a blend of traditional teaching methods and technology-driven activities. I will introduce a new algebraic concept through a brief lecture. I also design activities that encourage learners to apply their knowledge through collaboration online using the GeoGebra tool. Assessment strategies involve technology as well, such as interactive exercises involving Kahoot. The goal is to create a cohesive and dynamic learning experience that leverages technology to make algebra lessons more engaging, interactive, and effective."*

From the findings above, the interviewed teachers acknowledged the potential of technology to create engaging learning experiences for their learners. These findings align with Mariam and Levan (2023), who reported that mathematics teachers use technology to promote learner engagement and learner-centeredness. However, the teachers also cautioned that it is crucial to consider learners' varying needs and backgrounds to ensure equitable access and support the development of their technology skills.

### 4.3.3 Teachers' Self-Reported Technical Skills

#### *4.3.3.1 Perception of TPACK Constructs*

Technical skill was one of the themes that emerged as mathematics teachers described their process in planning lessons that integrated technology. The primary data used for this research came from demographic open-ended questionnaires, journal reflection and semi-structured interviews. Table 4.2 shows a breakdown of the mathematics teachers' responses to the questions in the demographic open-ended questionnaires. This step began with the results of ten mathematics teachers describing their lesson planning before the workshop.

Mathematics teachers were asked to rate their perceived TPACK constructs knowledge on a three-key scale rating from agree, neutral and disagree. Table 4.2 and Figure 4.2 show the findings, respectively.

| **Item No and TPACK** | **Perceptions about TPACK constructs** | Agree | Neutral | Disagree |
|---|---|---|---|---|
| TK | I have advanced technological knowledge for planning technology-integrated lesson | 4 | 1 | 5 |
| CK | I have advanced content knowledge of algebra | 8 | 2 | 0 |
| PK | I have advanced pedagogical knowledge to teach algebra | 7 | 1 | 1 |
| PCK | I have advanced pedagogical content knowledge to teach algebra | 8 | 1 | 1 |
| TCK | I have advanced technological content knowledge for planning technology-integrated lesson | 2 | 2 | 6 |
| TPK | I have advanced technological pedagogical knowledge for planning technology-integrated lesson | 1 | 3 | 5 |
| TPACK | I have advanced technological pedagogical content knowledge for planning technology-integrated lesson | 4 | 1 | 5 |

*Table 4.2 shows self-reported TPACK constructs for mathematics teachers extracted from questionnaires(n=10).*

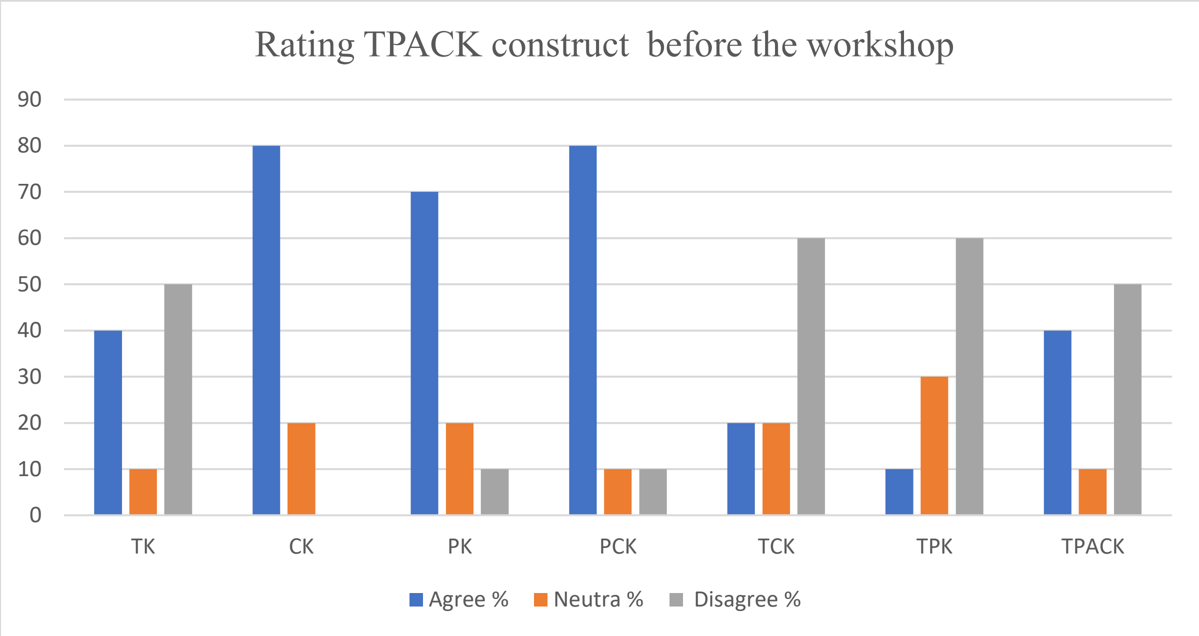


*Figure 4.2: mathematics teachers' self-reported TPACK before the workshop*

**Technological Knowledge (TK)**

Table 4.2 and Fig. 4. 2 illustrate that four participants, which is 40% of the participants, agree that they possess technological knowledge to plan technology-integrated lessons. One participant, which is 10%, indicated neutral about having technological knowledge. Half of the participants, 50%, disagree that they possess technological knowledge. Mathematics teachers were asked to define TK, and many defined TK as knowledge needed to operate certain technologies.

**Content Knowledge (CK)**

On perceived content knowledge before the workshop, eight participants, 80% of the participants, agree that they possess content knowledge of algebra. Two participants, which is 20%, indicated neutral about having content knowledge. No participants, which is 0%, disagree that they have content knowledge.

**Pedagogical Knowledge (PK)**

Seven participants, which is 70% of the participants, agree that they have pedagogical knowledge. Two participants, which is 20%, indicated neutral about possessing pedagogical knowledge and one participant, 10%, disagreed that they possess pedagogical knowledge, as shown in Table 4.2 and Fig. 4.2 above.

**Pedagogical Content Knowledge (PCK)**

In response to rating perceived pedagogical content knowledge, eight participants, which is 80% of the participants, agree that they have pedagogical content knowledge. One participant, 10%, indicated neutral about possessing pedagogical content knowledge and one participant, 10%, disagreed that they possess pedagogical content knowledge, as shown in Table 4.2 and Fig. 4.2 above.

**Technological Content Knowledge (TCK)**

Two participants, which is 20% of the participants, agree that they have technological content knowledge to plan technology-integrated lessons. Another two participants, which is 20%, indicated neutral about having knowledge of technological content. Six participants, 60%, disagree that they have pedagogical content knowledge, as shown in Table 4.2 and Fig. 4.2 above.

**Technological Pedagogical Knowledge (TPK)**

Data shows that one participant, which is 10% of the participants, agrees that they possess technological pedagogical knowledge to plan for technology-integrated lessons. Three participants, 30%, indicated neutral about having technological pedagogical knowledge, and six participants, 60%, disagreed that they possess technological pedagogical knowledge, as shown in Table 4.2 and Fig. 4.2 above.

**Technological Pedagogical Content Knowledge (TPACK)**

Four participants, which is 40% of the participants, agree that they have knowledge of technological pedagogical content. One participant, 10%, indicated neutrality about possessing technological pedagogical content knowledge, and five participants, 50%, disagreed that they have technological pedagogical content knowledge, as shown in Table 4.2 and Fig. 4.2 above.

#### 4.3.3.2 Ability to plan technology-integrated lessons

Mathematics teachers were asked to describe their ability to plan for technology-integrated lessons before the workshop in a comment section in the demographic open-ended questionnaires. Some mathematics teachers commented that they lack the skills to plan for technology-integrated lessons. Therefore, this makes it difficult to determine the technology suitable for the content they want to teach before participating in the lesson planning workshop. However, they find it easy to operate a particular technology for their personal use. This was revealed by T1-Q, who indicated in the comment section:

> *"There are some topics where it gets difficult to find appropriate technology that matches to deliver mathematics content, but as for the personal uses, I always do not struggle with using technology for my own use."*

Similarly, T7-Q Commented on the comment section as follows:

> *"I always struggle with setting up technology-integrated lessons. For instance, I prefer integrating YouTube videos, but I always waste time due to technical problems or the video content may not match my lesson goal. I always find it easier to use, for instance, printed materials and textbooks as a teaching aid in algebra lessons than technologies, which is time-consuming."*

It can be deduced from the data that some mathematics teachers struggled to integrate technology before the workshop. Three mathematics teachers revealed that they have a positive perception of integrating technology into their lessons, but they hardly plan to integrate technology into their lesson:

> *"I hardly plan to use technologies in my lessons due to a lack of skills. However, I may grab, for example, a phone to show something to my learners without planning about it" (T7-Q).*

Furthermore, T9-Q also commented,

> "*I still don't have any ideas as to how I can plan to integrate technology. Although the technology could be available, I couldn't figure out how to use it in my lesson. I wish I could be guided on how to do so,"*

T3-Q said*:" In my case, I think I know more about technologies, and I can operate most of them well. However, it was my first-time hearing about planning to use technology. I believe it would make a difference, though.".*

The comments from mathematics teachers indicate that they seem to possess technological knowledge and are using technology in teaching; however, they do not sequence their lessons as to how they intend to use such technology.

On the other hand, this finding is against Kohler and Mishra's (2006) argument that technological knowledge needs to be related to pedagogical and content knowledge, necessitating teachers to plan for technology integration for effective teaching with technology. Therefore, this sounds like a call for mathematics teachers' workshop on planning for algebra lessons that integrate technology. The data from the field notes indicated that mathematics teachers did not differentiate between technological Knowledge and TPACK. They thought with technological knowledge alone, and they could integrate technology successfully.

> "*For me, I know a lot about various technologies that we can use in mathematics lessons. Therefore, integrating technology would be easier for me." (T3-FN).*

However, scholars concur that successful technology integration should primarily be rooted in curriculum content-related learning processes, supplemented by the effective utilization of educational technologies (Durak,2021; Harris, et al., 2010), and this requires teachers to plan for their practical technology-integrated lessons.

It can be deduced from the data that mathematics teachers recognize the need to plan to integrate technology, but they are not doing so. T5-Q supports this statement by commenting as follows:

> *" I recognize the need to sequence my lesson to use various technologies in teaching and learning algebra, but I mostly have no confidence to do so".*

In general observation, mathematics teachers indicated that they foresee the need for technology integration, although they are unclear on how to plan. Therefore, 60% of them indicated that they do not know how the technology they integrate fits the pedagogy. In addition, it could be deduced from the data that most mathematics lack the necessary knowledge to plan successful technology-integrated lessons (TPACK) and must be guided on integrating technology. T10-Q indicated this in the comment section that:

> "*I hardly consider how my lesson that integrates technology fits my teaching method because I have no idea how. I believe more training is needed to fully equip teachers on using technology and its integration in day-to-day teaching and learning*".

The researcher observed from the data that most mathematics teachers believed that although they may possess technological knowledge, they still struggle to integrate the technology that fits their pedagogy, as most of them indicated in their comments. Additionally, T8-Q commented as follows:

> *"I wish school management intervene in the issue of technology integration. It seems like it is omitted in professional development and left in the hands of teachers themselves".*

This implies that mathematics teachers have technological knowledge but lack technological pedagogical and technological content knowledge, so they are not confident enough to incorporate technologies into their lessons. These responses lay a foundation for the need for lessoning workshops for teachers to develop the knowledge that could afford them to plan and integrate technologies successfully in their lessons.

#### 4.3.3.3 Lesson plans TPACK assessment after the workshop.

Each mathematics teacher was asked to provide three lesson plans after participating in the lesson planning workshop so that they could be used for document analysis. They planned lessons that integrated various technologies in algebra, considering their own context. The most technological tools that were used are GeoGebra, Kahoot and YouTube videos. The mathematics syllabus, curriculum, and assessment policy were used to evaluate how mathematics teachers adhered to the right curriculum goals and assessment requirements as stated in the mathematics syllabus. Figure 4.3: shows a YouTube video integrated lesson plan planned during the workshop by T-7.

**Lesson Plan: Algebra - Factorization by Grouping integrating YouTube Video**

**Grade: 9** **Duration: 40 minutes**

**Grade Subject: Mathematics** **Topic: Algebra  Manipulation**

**Lesson objective**: Factorise expressions by taking out a common factor and by grouping terms with simple grouping

**Technological tool to be integrated:** YouTube video

**Teaching Aids;** Laptop, internet access, Projector, YouTube video on factorization by grouping (pre-selected and reviewed, Chalk, Handouts with practice problems.

Procedure:

1. Introduction (4 minutes): a. Begin the lesson by asking learners if they can  remember the distributive property of multiplication over addition: a(b + c) = ab + ac. b. Explain that factorization is the reverse process of the distributive property and helps in simplifying algebraic expressions. c. Introduce the concept of factorization by grouping and explain that it is used when we have a quadratic expression that cannot be factored using other methods.
2. Steps for Factorization by Grouping (10 minutes): a. Write down a quadratic expression on the board, such as $5x^2 - 15x + 3x - 9x$  Explain the steps for factorization by grouping:
3. YouTube Video Presentation (12 minutes): a. Inform learners that they will be watching a YouTube video on factorization by grouping to enhance their understanding. b. Set up the projector and open the pre-selected YouTube video. c. Ensure that the video provides clear explanations and examples related to factorization by grouping. d. Play the video and ask learners to pay close attention and write the summary. I will Pause the video at key points to clarify concepts, answer questions, or engage learners in discussions.
4. Discussion and Concept Reinforcement (6 minutes): a. After watching the video, initiate a class discussion to reinforce the concepts covered.
5. Practice Activity (10 minutes): a. Distribute handouts with practice problems to the learners or display the problems on a screen. b. Instruct learners to factorize the given quadratic expressions using the method of grouping. c. Circulate around the classroom, providing assistance and feedback to learners as they work. d. After the practice session, discuss the solutions as a class, clarifying any misconceptions or difficulties encountered.
6. Wrap-up and Conclusion (4 minutes): a. Recap the steps for factorization by grouping and highlight the importance of checking the factored expression using multiplication. b Answer any remaining questions from learners and address any challenges they encountered during the lesson. c. Assign the exercises below: Factorize the following by grouping.

a) $a^3 + 2ab - 4a^2 + 8b$ b) $5y^3 - 10y^3 + 6z - 12z^3$
b) $11p - mp + 11r - mr$ d) $P^2q + p^2r + q + r$
c) e)$6xy + 7xm - 12y + 14m$

Reflection of the lesson:

…………………………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………………………

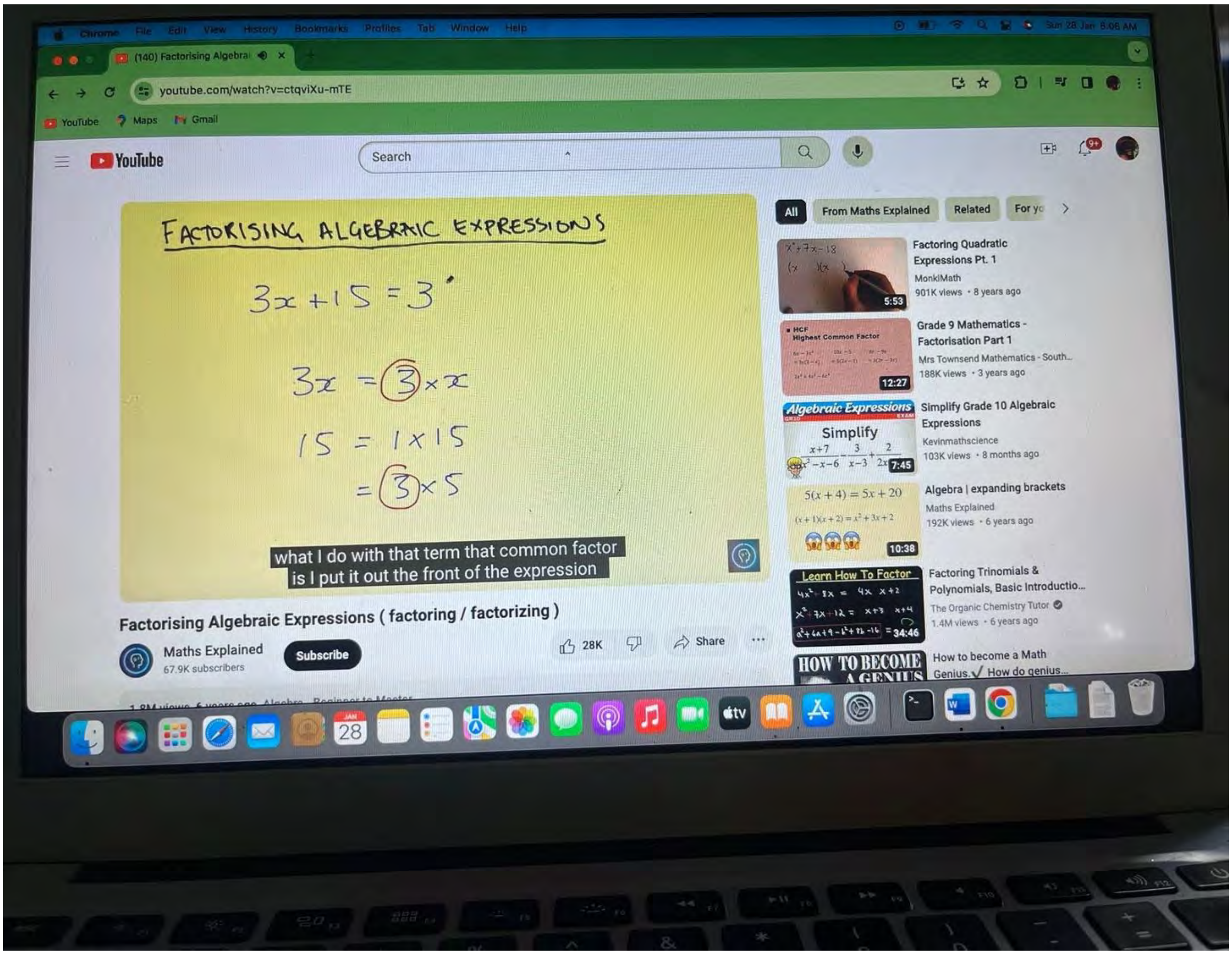


*Figure 4.4: Show a YouTube vide planned to be integrated into the algebra lesson planned above.*

The lesson in figure 4.3 planned during the workshop was commented for necessary improvements. The lesson objective states factorizing by grouping, with four terms. However, the YouTube video planned to be used consists of presentation on factorizing by taking out common factors. Although both lesson objectives and the video content are about algebra factorizing, it can be argued that this video does not present the right level of taxonomy as stipulated by the syllabus for mathematics grade 9. The comments made was to re-consider the content of the video to present factorizing by grouping with four terms. The lesson also highlighted the teaching aids such as white bord, internet, chalkboard, laptop, and handouts, needed to support the use of YouTube video, which mathematics teachers referred to as supportive tools after the workshop.

**Lesson Plan: Algebra - Factorization by taking out common factors integrating** Kahoot technology
**Grade Level: 9** **Duration: 40 minutes**
**Grade Subject: Mathematics** **Topic: Algebra Manipulation**
**Lesson objective**: Factorise expressions by taking out a common factor and by grouping terms with simple grouping

**Technological tool to be integrated: Kahoot**

- **Supportive tools:** Devices (laptops, tablets, or smartphones) for each student to participate in Kahoot, internet access, Chalk bord, Kahoot account (created and set up prior to the lesson), overhead projector, or smartboard for displaying the Kahoot game, soft copy document with practical problems.

1. Introduction (5 minutes):
   - Greet the learners and briefly explain the objective of the lesson.
   - Ask the learners if they are familiar with the concept of factors and factorization.
   - Recap the definition of factors and remind learnerss how to find common factors of a number.
2. Discussion on Common Factors (5 minutes):
   - Write the term "Common Factors" on the board.
   - Define common factors as the factors that two or more numbers have in common.
   - Provide examples of $3x^2$ and 6xy and ask the learners to find the common factors between them.
   - Facilitate a class discussion on the importance of common factors in factorization.
3. Step-by-Step explain Factorization Method (10minutes):

Explain the step-by-step process of factorization using common factors. Start with: (a) $4x+8x^3$, (b) 21xy + 14x (c) 9h-15, simple examples and gradually increase the complexity. (d) 2x + xy-x, (e)12gh-9gh+18gh (f) 5suv-10sv+15su

Demonstrate the process on the board, encouraging learners to ask questions along the way and emphasize the importance of finding the greatest common factor (HCF) when factoring.

4. Kahoot Assessment (15 minutes):
   - Explain that an interactive Kahoot game will be used to assess their understanding of factorization using common factors.
   - Ask the learners to take out their devices (laptops, tablets, or smartphones).
   - Launch the pre-created Kahoot game on the projector or smartboard.
   - Provide the Kahoot PIN for learnerss to join the game.
   - Guide the learners through the Kahoot assessment, which should include multiple-choice questions, true/false statements, and identifying factors and encourage active participation and engagement.
5. Recap and Discussion (5 minutes):
   - Summarize the main points of the lesson, emphasizing the importance of common factors in factorization.
   - Address any misconceptions that arose during the lesson.
6. Extensions and Differentiation:

- For fast learners, provide additional challenging problems for factorization.
- For struggling learners, provide more guided practice and one-on-one support during the activity.

Note: Prior to the lesson, create a Kahoot game that includes questions related to factorization using common factors. Make sure to cover different aspects of the topic, including identifying factors, finding the greatest common factor (HCF), and performing factorization. Test the Kahoot game beforehand to ensure it functions properly and aligns with the lesson objectives

7. Reflection for the lesson: ……………………………………………………………………………………

*Figure 4.5: Shows the sample of a Kahoot integrated lesson plan that was submitted after the workshop by T-4 with the Kahoot Game activity that is planned to be integrated.*

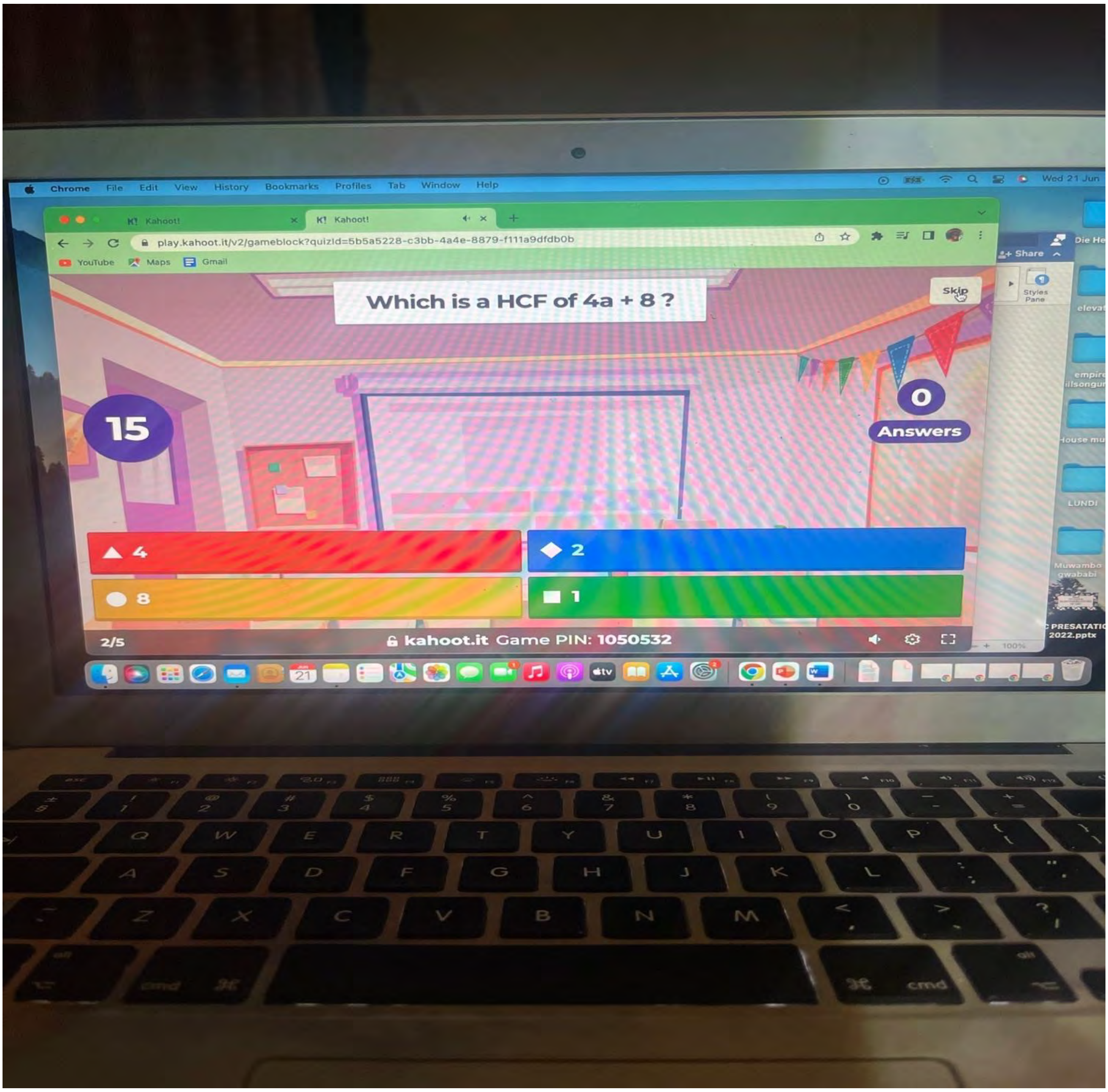


*Figure 4. 6: Shows a Kahoot Game planned to be used for assessment purpose for the planned lesson above.*

The lesson plan above was submitted by T-4. It clearly indicated that the Kahoot Game was planned to be used for assessment purposes, after the lesson presentation. The questions in the Kahoot game reflects the correct taxonomy of the lesson objectives on the lesson plan as stipulated in grade 9 mathematics assessment policy, see figure 2.2. This lesson plan highlights how learners will engage with Kahoot and the activities for slow and fast learners. The lesson highlighted the supportive tools such as internet, cellphones, smartboard, projector, chalkboard and handouts as tools needed for integrating Kahoot into the lesson.

Bloom's Taxonomy and TPACK framework was used to analyze TPACK development for mathematics teachers. This data was used for triangulation with the data from questionnaires, journal reflections and interviews. The lesson plans were analyzed using the TPACK evaluation tool, Technology Integration Rubric (TIR) developed by Harris et al. (2012), see **Appendix G**. The rubric is designed with the integration of technology within four categories. The first three categories relate to technology integration as it fits within the TPACK framework. Category one is associated with Technological Content Knowledge (TCK), category two articulates Technological Pedagogical Knowledge (TPK), category three aligns with Pedagogical Content Knowledge (PCK), and finally, category four looks at the overall fit within the conceptual framework of TPACK. On this rubric, a score of four indicates a strong or exemplary example of the construct. A three means that the TIR is aligned, supports, or is appropriate. Two indicates that the TIR partially, minimally, marginally, or somewhat fits the lesson. Finally, one does not align, does not support, is inappropriate, and the TIR does not fit with the lesson plan. Table 4.3 contains the results of each of the mathematics teachers (n=10) based on the scoring rubric, and Figure 4.7 contains the percentages of each score.

Based on the data collected in Table 4.3**,** the cohort produced a median TPACK score of 15, which provides a significant measure of TPACK integration and knowledge among mathematics teachers. Further analysis of the TPACK score in Table 4.3 shows that the lowest TPACK score of n=10 was an 8, which represented one individual out of the ten mathematics teachers, which is 10%.

*Table 4.3 Technology Integration Rubric Results from Lesson Plans Assessment*

| | **Curriculum Goals & Technologies** | **Instructional Strategies & Technologies** | **Technology Selection(s)** | **"Fit"** | **Total Score** |
|---|---|---|---|---|---|
| **T1** | 4 | 4 | 4 | 4 | 16 |
| **T2** | 3 | 3 | 3 | 3 | 12 |
| **T3** | 4 | 4 | 4 | 4 | 16 |
| **T4** | 3 | 3 | 3 | 4 | 13 |
| **T5** | 4 | 4 | 4 | 4 | 16 |
| **T6** | 4 | 4 | 2 | 4 | 15 |
| **T7** | 2 | 2 | 2 | 2 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| **T8** | 4 | 4 | 4 | 4 | 16 |
| **T9** | 4 | 4 | 3 | 4 | 15 |
| **T10** | 4 | 4 | 4 | 4 | 16 |

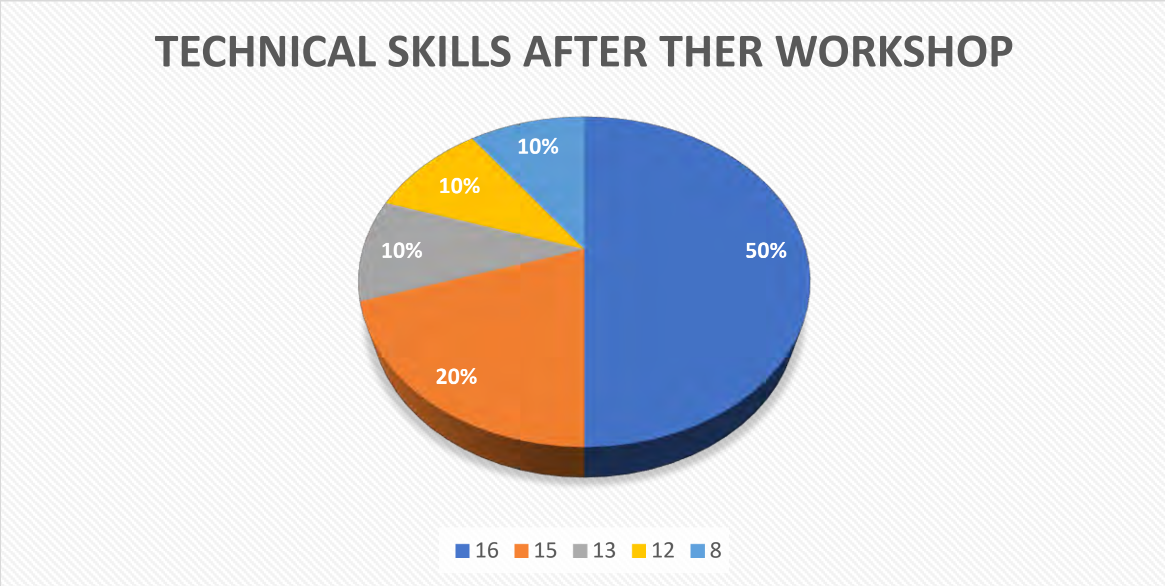


*Figure 4.7 shows the total percentage of TPACK scores that were recorded from lesson plans, N=10.*

The range of possible scores was 4 to 16 based upon the rubric in **Appendix G. Figure 4.3** shows the total percent of the scores recorded for the cohort. This indicates that nearly half of the participants were advanced and proficient with TPACK, scoring 100% on their lesson plans TPACK assessment. The remaining proficient or nearing proficient when providing a rationale for integrating technology within their lesson planning process. The data shows that 10% of the participants scored low in planning for technology that fit content (TCK). It also shows that the lesson planning workshop, as it relates to TPACK, may have had some causal impact on the way mathematics teachers planned with technology in their minds. This coincides with the findings by Harris et al. (2011). The results indicate that mathematics teachers have good understanding of TPACK domains.

Nevertheless, after the workshop, some mathematics teachers also described their lessons that integrate technology showing good understanding of TPACK. As they clarified how they consider their technology-integrated lesson planned fit content to be taught such that T7-I Clarified:

> *"So ...for me, I considered Bloom's taxonomy level when planning algebra lessons that integrate technology. In my experience, I found a YouTube video for algebra with*

*content that explains identifying like terms in algebra, while, my lesson competency requires my learners to apply the algebra rule to factorize. I considered that using this video alone may not afford my lesson objective because the content is the same but the taxonomy level is different."*

Echoing similar**,** T9-R contended that:

*"When planning activities, I have to consider the objective and level of taxonomy. For instance, the objective for algebra lesson I planned was factorizing, which is the application level of the taxonomy. Thus, the tools that I used are the ones that could offer my learners an opportunity to apply, hence, learning the right taxonomy about the objective."*

*"….I used Kahoot and designed the activities about identifying like terms, which is remembering rather than factorizing, which is application. I could not use GeoGebra, which could offer my learners the opportunity to apply knowledge, but Kahoot, which is for remembering because I wanted my learners to remember what they have learned from my lesson." (T5-R)*

After participating in the workshop, mathematics teachers could describe how their planned technology-integrated lessons fit pedagogy in more detail. They indicated where and how they intended to integrate each tool for each pedagogy. For instance, they recognize the need to use two technologies in one lesson that fit each teaching method. This was revealed in T4-RJ, described as follows:

"*The technology I chose was determined mainly by the lesson objective, factorizing expression. Firstly, learners needed to understand the term factorizing and the rules of indices. Therefore, I used YouTube videos for the introduction. After I presented the lesson, learners used the Algebrator tool to answer different questions on factorizing, starting with simple questions and then moving on to complex questions.*"

The findings from this study reveal that through planning algebra lessons, teachers have developed the necessary knowledge to integrate technology, as proposed by Harris & Hoffer, 2011. Additionally, mathematics teachers described their technology-integrated lessons through journal reflections and interviews in more detail, and they considered additional factors carefully. They described their lesson planning in more detail after the workshop, clearly indicating what activities learners would use the technology in their lessons. Still, they considered additional factors that may affect the success of their technology-integrated lessons, such as shortcoming considerations, improvision in case of internet failure, and supportive tools. This was revealed by T8-I, who responded that:

> "*There might be some shortcomings when it comes to integrating technology in the lesson. For instance, the Kahoot technological tool that I planned to use in my lesson requires internet access and a projector/ smartboard. Due to lack of this, I might not be able to use the program; nevertheless, we could improvise by using a pocket WIFI, hotspots from cell phones to access the internet and borrowing a projector to use technology efficiently in teaching*".

The data from the field notes that were taken during the workshop also noted that mathematics teachers commented that:

> "*There are always shortcomings that may arise while integrating technology in the lesson, no matter how good your technological knowledge is, and they may fail the success of the technology-integrated lesson. Things like weak internet, power trapping, and faults in connection, hardware, and software functionality. One should always be on the lookout for backups with supportive tools in case of any shortcomings that may arise." (T*4-FN)

Mathematics teachers highlighted during journal reflection that, in order to integrate technology such as GeoGebra or Kahoot, there should be supportive tools such as a laptop, internet, smart board and overhead projector. Mathematics teachers referred to supportive tools as the tools that could support the integration of the intended technological tool success, such as the internet. However, some mathematics teachers seem confused between the supportive tools and the tools to be integrated for teaching and learning, for instance, Kahoot.

**4.4 Research Question 2.**

**What opportunities are offered or not, to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology in the Oshakati education circuit?**

To provide a collective answer to research question two, relevant data from workshops, journal reflections, interviews and document analysis were collated and analyzed. The themes that emerged from the findings are displayed in Table 4.4.

| [redacted] | |
|---|---|
| ***1.*** | Advance the state of knowledge regarding applying and utilizing specific technologies. |
| ***2.*** | Acquiring the ability to integrate technology and content proportionately. |
| ***3.*** | Gaining knowledge on how to improve teaching outcomes by effectively incorporating technology. |
| | |

*Table 4.4 shows themes emerged for research question two.*

The findings are presented as themes in response to the guide research question and supported by participant quotes from interviews and workshop discussions. The data analysis found that mathematics teachers encountered a range of opportunities that enabled them to develop their technological Pedagogical Content Knowledge (TPACK) while planning algebra lessons that incorporate technology. These opportunities are presented and discussed in detail below.

### 4.4.1 Advance the state of knowledge regarding applying and utilizing specific technologies

In this study, all mathematics teachers indicated that preparing mathematics lesson plans with integrated technology improves their Technological Knowledge (TK) as it gives them a chance to learn new ways to use specific technologies in mathematics instruction. By planning to incorporate technology in their lessons, the teachers learned how to use specific software or technologies that are effective in teaching mathematics. They also acquired an understanding of the benefits of technology integration and were capable of making informed decisions regarding its incorporation into classroom settings.

Some mathematics teachers noted that integrating technology into their lesson plans introduced them to a range of technological tools and showed them how these could be introduced in educational contexts. Despite having considerable experience in teaching mathematics and access to technology, the discussion during the sharing workshop revealed this was their first attempt at creating mathematics lessons that included technology. Consequently, their limited familiarity with integrating technology into lesson planning presented challenges in effectively utilizing specific technological tools. However, T5's account provides a clear example of their development of technological knowledge,

*"I learned how to use different technology, not just YouTube. I now know how to use Kahoot and Gamification in my lessons, which makes them more interesting. Before, I didn't have much experience using technology in teaching because this was my first time integrating it into the lesson plan for the algebra topic." (*T5-I)

Throughout the interviews, teachers admitted to observing a certain level of improvement in their technological understanding. T3-RJ expressed,

*"I believe I have grown more mindful of some technologies I can use in my math lessons, along with the techniques for effectively implementing them."*

T2-RJ had this to say:

*I can say my TK has shifted ahead. Now, I consider more things than before, such as context, content, availability of tools, and supportive tools. In fact, technological knowledge has shifted as we discussed using different tools with my colleagues. My technological pedagogical knowledge has improved. However, my content knowledge remained the same.*

During the interviews, emotional responses were frequently expressed, which was found to be associated with the mathematics teachers reporting limited technological pedagogical knowledge before the workshop. The possession of little technological pedagogical knowledge while preparing a lesson incorporating technology could lead to emotionally intense reactions: T4 expressed

*"But, but..aa. I sometimes undoubtedly felt quite annoyed and highly frustrated when I lacked knowledge about teaching with technologies recommended by my colleagues during the workshop discussions to be suitable to incorporate into teaching mathematics. This feeling tends to happen throughout the process, eventually allowing me to learn more about teaching with such technologies." (*T4-FGI)

However, T9-RJ responded that she experienced a minimal shift in her Pedagogical and Content Knowledge (PCK) alone, but her Technological Pedagogical Knowledge (TPK) has a significant improvement. Mathematics teachers also indicated that some types of teaching strategies they discussed to incorporate during the lesson planning workshop were familiar.

*"I can say I have experienced nothing new really in terms of subject knowledge and pedagogical skills. However, my technological pedagogical knowledge has shifted. Mostly, I had an opportunity to reconsider technologies that fits well with certain teaching strategies" (*T9-RJ)

Similarly, T10-RJ expressed that:

*"I have mastered mathematics content before. However, the issue of incorporating technology to teach the content has not been in my experience before. I have learned how to combine technology with content in my lesson planning."*

It can be deduced from the findings that mostly during lesson planning, most mathematics teachers improved their TK, TCK and TPK while, the findings revealed that mathematics teachers' CK and PK reported no change.

### 4.4.2 Acquiring the ability to integrate technology and content proportionately

Most mathematics teachers indicated they developed a more profound comprehension of harmoniously integrating technology and content. However, T6 noted that due to their limited Technological Content Knowledge (TCK) before participating in this study, they encountered difficulties in identifying the most suitable technology for teaching mathematics content. However, through the process of recontextualization, as mathematics teachers plan the lessons that integrate technology considering their context after the workshop, T2 believed they understood how to introduce technology and content in a well-balanced manner. T6-RJ stated:

"*Participation in the workshops in this study was very helpful for me because I was constantly unsure how to effectively introduce technology, teaching, and content together in a way that works well. After practically designing my lesson considering my context, I am particularly experiencing ways to clearly explain how the technologies are connected to the content and pedagogy."*

This supports the finding of Koh's (2020) study that emphasized the significance of learning by design as a crucial element in developing TPACK skills and effectively integrating technology. In addition to balancing content and technology, some mathematics teachers reported that they occasionally lack the ability to choose suitable integrated technology, as the available technology in schools may not align with the content delivery. This results in lesson planning and curriculum development that do not involve the use of technology. T1 provided an instance where one of her colleagues expressed discontent regarding teaching the topic factorization' and the lack of adequate resources,

> "*…if she can't teach the lesson using the technology available at the school, she presents her lesson without technology integration.*" "T1-FGI"

Similar sentiments were expressed, and comparable opinions were expressed due to insufficient knowledge of technological content or other limitations related to technology skills, such as the lack of technical support to resolve issues with computer functionality and poor internet connectivity at school. In the same vein, T4-RJ argued that:

> "*I realized that I have been using technology rather than integrating as I learned that integration of technology means technology is used in such a way that it affords the lesson objective to be met. I believe it is safe not to use the technology that may destroy my lesson because now I know the difference between mere use of technology and technology integration".*

### 4.4.3 Gaining knowledge on how to improve teaching outcomes by effectively incorporating technology

All mathematics teachers expressed that the workshop provided valuable insights into improving teaching effectiveness using technology. Specifically, T3 mentioned that while planning lessons that integrate technology, she better understood how to use technology effectively in teaching. She intends to use two computers, one for displaying PowerPoint presentations and another for hosting Kahoot! Application. Furthermore, she expressed the desire to learn how to switch between the two computers to display content from both on the large screen.

The workshop allowed some mathematics teachers to enhance their comprehension regarding how pedagogy and technology interrelate and impact one another. Through workshops and feedback on their technological tool choices from other participants, mathematics teachers developed their Technological Content Knowledge (TPK), which gives them the confidence to integrate technology. Additionally, the intervention helped participants gain insights on how to use the technologies beyond information transmission, thus developing their technological Pedagogical Content Knowledge (TPACK). These findings align with Alemdag et al. (2019), who found that active participation in collaborative, hands-on activities was crucial in developing teachers' Technological Content Knowledge (TPACK). For instance, it was observed in T4 lesson plans that she aimed to explore learner-centered approaches when using technology in the classroom. For assessment purposes, she planned to use Kahoot, and her technological knowledge informed her choice of the assessment method. Furthermore, T-6 lesson plans suggest that she intends to encourage learners’ use of GeoGebra in the classroom.

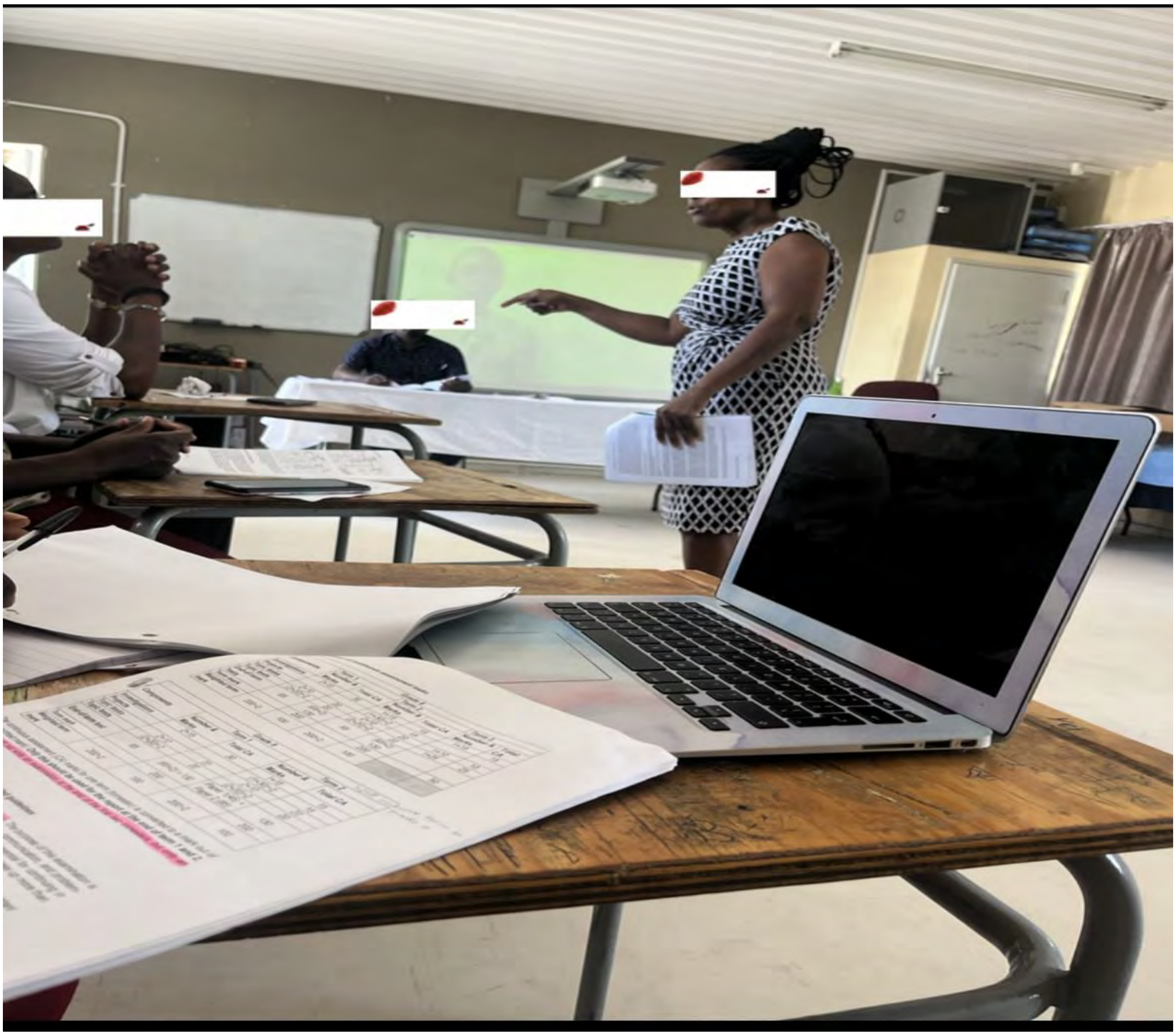

*Figure 4.8: Shows mathematics teachers discussing the algebra video integrated lesson plan, planned during the workshop.*

After planning the algebra lessons that integrate technology during the workshop, mathematics teachers discussed their planned lessons for necessary improvements as seen in the picture above. It came out that most videos planned to be used during the lessons were not designed during this workshop, but were sourced from YouTube and online plat forms. However, the Kahoot games were created by teachers themselves with the pin for access to the question.

Most comments were directed on how the planned technology activities reflected the syllabus content and how best one can use such technology in the lesson, during introduction, presentation or during assessment. The findings revealed that workshop discussion allowed mathematics teachers to think and re-think how the available technology afford or limits the achievements of their lesson's objectives as revealed by T2, T3 and T5 as follow:

> *"While preparing for my technology-integrated lesson and discussing our lesson plans. I spent a significant amount of time suggesting various technologies and considering their potential impact on my teaching, especially since we discussed our lesson plans during the workshop*" (T2-RJ)

> *"Participating in planning lessons that integrate technology has helped me become more aware of how to present my lessons interestingly to my learners. This involves considering activities for both slow and fast learners. I have also explored many technologies that could help me achieve my lesson objectives. After careful consideration, I confidently chose to use Gamification technology because it offers a fun way to engage my learners during lessons." (*T3-SI)

> *"I see-aa… attending a lesson planning workshop has encouraged me to carefully consider my teaching approach and the technology that best aligns with my pedagogy and assessment requirements. For example, when assessing my learners during or after the lesson, I incorporated algebra video clips from YouTube as an introduction to the topic. This is because learners need to remember the algebra rules from the previous grade. Videos are easy to operate, allowing me to pause, stop or forward to facilitate questioning. This gives me the confidence to work with technology."* (T5-FGI)

During the workshop mathematic teachers had time to criticize their planned activities in regard to subject policy, syllabus and assessment policy as seen in figure 4.9 below.

*Figure 4.9: Shows mathematics teachers commenting on lessons planned during the workshop considering subject policy.*

The lesson plans that teachers shared also indicate technology integration in lessons and the broader context of education. This context includes various aspects, such as the school and classroom environment, which heavily influence the teachers' understanding and use of technology, their teaching methods, and the combination of the two. In fact, how they integrate technology, teaching methods, and content significantly depends on the setting in which they are applied. Teachers stress the crucial need to comprehend the contextual factors influencing their teaching and learners' learning, as this awareness helps them make better choices on incorporating technology into their lessons effectively. T6-RJ further explained that:

> "*There are chances that the technology planned to be used may have the wrong content. Therefore, I have to make sure the Kahoot that I plan to use, for instance, consists of the right content and that my assessment would address the right taxonomy level to enhance performance. For example, the objective for the algebra lesson that I plan is the application of the rule to factorize. I made sure that the content in my video or Kahoot was not only about the knowledge level of taxonomy but also the application level, which is required by the syllabus for mathematics*."

Mathematics teachers revealed that participating in the workshop on planning for algebra lessons that integrate technology offered them opportunities to enhance their TPACK as it made them more aware of using technology effectively, improving mathematics performance. This finding is in line with the study by Onyema (2020) and Viberg, Grönlund, & Andersson, (2023), which revealed that effective integrating technology in the teaching of mathematics can enhance learners' learning outcomes

### 4.5 Research Question 3

**How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology?**

The findings for this question was sourced from the interviews, and these findings were confirmed with data from journal reflection and field notes. The themes emerged are noted in Table 4.5.

| | |
|---|---|
| ***1.*** | Continuous professional development in planning lessons that integrate technology |
| ***2.*** | Technical support |

*Table 4.5: Themes emerged for research question 3.*

#### 4.5.1 Continuous professional development workshops on planning lessons that integrate technology

The data from interviews revealed that most mathematics teachers responded almost similarly that they could be supported to develop TPACK by participating in continuous professional development targeting planning lessons that integrate technology. For instance, T5-FGI stated that:

*"I think we need more training. Aa…I mean to participate in a professional development workshop focusing on technology, which must be done continuously as technology is continuously changing. These continuous professional developments should target planning lessons that integrate technology."*

Similarly, T8-RJ commented*: Before participating in the workshop, I wasn't so eager to learn about new apps and new stuff that I could use for my learners. So, after the planning lessons integrating technology, I was very excited and wanted to learn more. I wanted to know more. Therefore, I believe planning lessons that integrate technology can support TPACK developments."*

T7-SI said, *"I feel we are not getting professional development, and we are not getting the professional support we need, so if we band together, we come up with solutions on our own. And we learn from other criticism."*

T1-SI posit *"Oh, aaa…I would recommend more continuous professional development workshops targeting lesson planning on lessons that integrate technology. I would say ongoing workshops, you know, just to keep up with current trends. You know, technology is continuously changing. I think that professional development is most important."*

T3-SI added, *"Mhm…. the government need to initiate ongoing training targeting developing TPACK rather than training only on technological knowledge alone. This training needs to highlight the importance of Bloom's Taxonomy in technology integration in education."*

### 4.5.2 Technical support

Some mathematics teachers suggested that the government offer technical support to schools because some schools' computers have outdated hardware and software programs, which brings several technical faults. T5-SI indicated:

"*I think schools need technical support mostly on software proficiency. I observed my school has un-updated windows, no antivirus and outdated software, making it difficult* *for teachers to plan to integrate technological tools, thus making these tools functional*."

*"The government should keep computer labs up-to-date with the latest software and security patches to prevent technical problems during the lessons. This can help us consider shortcomings that may arise when planning to integrate technologies." (*T2-I)

Furthermore, T3-FGI posits that:

*"We need access to various digital resources such as up-to-date educational websites and online databases. The Ministry of Education is supposed to provide resources that align with the curriculum and suitable level of Bloom's Taxonomy."*

Some mathematics teachers indicated they could be supported by providing technical support such as troubleshooting and online community forums. (T9-I) claim:

"Sometimes *I may get stuck with technical issues like network connectivity, hardware and software operation, for example, and no matter how well I plan to integrate technology, some faults may occur in the classroom. I think teachers should have access to a reliable technical support team or helpdesk that can assist."*

Field note data taken during the workshop noted that T10-FN highlighted that:

"*I think this should be a starting point for us to continuously meet, even online, such as Zoom meetings or What-up groups to plan and discuss our work. I believe it could help us improve our technology integration competencies."*

During the workshop discussions, participants suggested to continue conducting lesson planning workshops even after the study ends. They highlighted that it is important for their professional development.

## 4.6 Summary of the chapter

In this chapter, findings generated from ten mathematics teachers were presented as guided by the three research questions posed at the beginning of this study based on:

1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology in the Oshakati education circuit?
2. What opportunities are offered or not, to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology in the Oshakati education circuit?
3. How can Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology?

The findings in this study unveiled that mathematics teachers had a positive perception of the use of technology in teaching mathematics. However, they do not plan for technology-integrated lessons. Mathematics teachers were able to describe the lessons that integrate technology in more detail (explicitly) after participating in the lesson planning workshop. The findings further revealed that planning algebra lessons that integrate technology enhances the development of technological content knowledge. The next chapter presents a discussion of this study's findings.

# CHAPTER FIVE: DISCUSSIONS OF FINDINGS

5.1 • Introduction

5.2 • Discussion of Key findings

5.3 • Summary of the chapter

## 5.1. Introduction

This chapter presents the discussion of findings pertaining to the three research questions. The research questions were addressed by utilizing multifaceted data collection tools encompassing the deployment of demographic open-ended questionnaires, conducting insightful semi-structured interviews, journal reflection, document analysis, and fostering dynamic discussions within focus group sessions. Each question is discussed separately, drawing on the existing literature and the theoretical framework presented in chapter two to support the explanation of the data provided by the participants. The presentation of this chapter is structured in sections according to (5.1) introduction, (5.2) discussion of key findings, and finally, (5.3) Summary of the chapter.

## 5.2. 5.2 Findings

*Table 5.1 shows the research questions and the instruments used*

| **Research Question** | **Instruments used** |
|---|---|
| 1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology? | Questionnaires, Journal reflection, Field notes, Interviews |
| 2. What opportunities are offered or not, to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology? | Journal reflection, Field notes<br>Interviews, documents |
| 3. How can Grade 9 mathematics teachers be supported to develop technological pedagogical content knowledge when | Interviews, Field notes, Reflective Journals |

| | |
|---|---|
| planning algebra lessons that integrate technology? | |

The findings reported in this chapter are discussed in relation to the research questions earlier summarized

**5.2.1: Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology.**

The first research question addressed the issues of mathematics teachers' technology access and usage, the rationale for technology use, teachers' self-reported technical skills and TPACK assessment from lesson plans. The demographic open-ended questionnaire, focus group and semi-structured interviews, journal reflection and field notes generated data to describe the commonly used technology tools for teaching mathematics and how they will be utilized.

**Mathematics teachers' technology access and usage**

The present study's findings revealed that mathematics teachers own and have access to various technological tools and have been integrating and using technologies for various purposes before participating in the workshop. The same findings about technology access in Namibia have been previously discovered by the studies conducted in Namibia by Kanandjembo (2021) and Munyanyo, (2023). However, this study further revealed that although mathematics teachers have access to and use various technologies, they have never planned to integrate the technologies they have been using. The main facilities they have been using are smartphones, tablets, data projectors, the internet, and computers.

This finding contradicts the findings about technological access challenges in most developing countries revealed from earlier studies (Assey & Babyegeya, 2022; Bantwini, 2017; Hlalele, 2014). Notably, most mathematics teachers spend over three hours daily on computers, laptops, tablets, or mobile phones for personal use, emphasizing the pervasive role of these devices beyond the classroom. However, despite using technology extensively for personal use, teachers reported allocating less time (only 2 to 3 hours daily) for lesson preparations. This finding suggests that teachers have access to computers, laptops, tablets, or mobile cell phones but mainly utilize them for personal purposes in their daily lives. This observation concurs with the notion of social interaction in which technology tools are not only confined to classroom use but are also embedded in society, where they are used for personal purposes (Henderson & Cunningham, 2023).

Furthermore, most mathematics teachers often use the internet for personal purposes and spend less time on educational purposes. This study's finding reveals that most mathematics teachers often use the internet, which contradicts the study by Kanandjebo (2022), in which she investigated a professional development framework for teaching mathematics meaningfully with technology in Namibia. Her study found that internet connection and shortage of technological tools were the most challenges experienced by mathematics teacher participants, and only a few teachers used MS Team, ZOOM, and Google Classroom. This contradiction could be due to several reasons. For example, the teachers only make an effort to access the internet and technological tools for their personal use rather than for educational purposes, while the use of specialized tools in education by only a few teachers could be due to a lack of knowledge to integrate technology observed elsewhere by Kopcha et al., (2020).

Regarding teachers' technology usage patterns and time allocation, the study revealed that most mathematics teachers use technologies for different purposes in their classrooms, such as for information sources and to create engaging lessons. However, some mathematics teachers indicated they are unsure when and where to use technology in their lessons. The data further reveals that mathematics teachers have been using technologies without planning to integrate them. According to Bernstein (1975), this is regarded as invisible or weak framing because when pedagogy is invisible, the teacher arranges the lesson without explicit activities for learners. So, within this context, the learner has more power over what he or she selects, how it is structured, and over the time scale, including his activities. Usually, this occurs when the teacher does not plan for their technology-integrated lesson.

On the other hand, using technological tools without planning could contribute to some mathematics teachers not being sure when, where and how to integrate technology considering the recommendations by Hollebrands (2020) and Yıldırım, Akcan and Öcal (2022), that when teachers sequence their lessons may know how to use a certain technology, which when used appropriately, is an important tool in the classroom. Therefore, as mentioned earlier, the researcher asserts that teachers' levels of technological skills and capacity to adapt to both the quality and quantity of curriculum are essential for success (Winter, Costello, O'Brien & Hickey, 2021). Nevertheless, the mathematics teachers in this study also emphasized the need for careful monitoring of learners to ensure responsible and effective utilization of technology while addressing concerns regarding learners' inappropriate access.

**Mathematics Teachers' Self-Reported Technological knowledge**

In this study, the results of the assessment of mathematics teachers' self-reported technological show the understanding of mathematics teachers' TPACK constructs (See Chapter 4, section 4.3.3). The result of the mathematics teacher's TK shows that some mathematics teachers have technological knowledge before participating in the workshop. This finding is based on how mathematics teachers understand TK, as most mathematics teachers define TK as knowledge needed to integrate technology. This implies that with TK alone, some mathematics teachers believed that they could integrate technology into their lesson plans. However, Koehler, Mishra & Cain (2013) elucidated that there is no single technology solution that applies to teaching and all teachers. Effective teaching requires developing a nuanced understanding of the complex relationships between technology, content, and pedagogy and using this understanding to develop appropriate, context-specific strategies and representations. On the contrary, many mathematics teachers indicate that they have advanced content knowledge about algebra. The results of PK show that many mathematics teachers have advanced PK before participating in the lesson planning workshop. This could be because most mathematics teachers in this study had five years or more of teaching experience.

Furthermore, the results of PCK of mathematics teachers indicate that they know the methodology they can plan to use for teaching their subjects. The results about TCK reveal that most mathematics teachers do not have TCK, which means that many do not know how to plan for such technology to present subject content. The results about teachers' TPK also revealed that mathematics teachers did not have TPK before participating in the workshop. Literature confirms that technological pedagogical content knowledge is the basis of good teaching with technology and requires understanding the representation of concepts using technologies (De Rossi & Trevisan, 2018; Makawawa et al., 2021).

The results about mathematics teachers' TPACK revealed that some teachers believed they had TPACK, although some were uncertain about having TPACK. Some study findings revealed that TPACK is regarded as the basis for teaching with technology. It requires understanding pedagogical techniques that use technologies constructively to strengthen previous knowledge and develop new knowledge (Koehler, & Mishra, 2016). The results about some mathematics teachers believing to have TPACK could be because some mathematic teachers did not differentiate between TK and TPACK when they defined the two constructs before participating in the workshop. This implies that mathematics teachers could find it difficult to plan lessons integrating technology because they do not understand TPACK before the workshop. Understanding TPACK among teachers can provide a coherent structure that allows them a better understanding of sound planning of lessons that integrate technology. Teachers with useful technology integration make practical decisions regarding learning content, teaching goals, and pedagogical methods and assess the lesson outcomes (Henriksen et al.,2016).

The results from document analysis evaluation of the lesson plans that mathematics teachers submitted after the workshop were triangulated with findings from the semi-structured interviews and journal reflection, and they yielded relevant findings. The results show that nearly half of the participants were advanced and proficient in TPACK constructs, scoring 100% on their lesson plans TPACK assessment. The document analysis results show that the lesson planning workshop has improved the mathematics teachers' understanding of the TPACK framework. The results also demonstrate how mathematics teachers' knowledge of TPK, TCK, and PCK are interrelated to form TPACK, and this points to how a teacher's descriptions of their planned lessons that integrate technology influenced by TPACK align with their intention in planning instruction that integrates technology.

To sum up, the findings of this study on how mathematics teachers describe algebra lesson plans that integrate technology indicate that mathematics teachers have improved the description of their lessons after participating in the workshop. The findings revealed that mathematics teachers planning lessons that integrate technology after the workshop considered the relationship among content, pedagogy, and technology as they describe their lesson in more detail than before. As indicated in Section 4.3.3, they considered other factors in their context, such as supportive tools, improvement, learners' needs, and shortcomings. They also considered content in detail as to how the content and pedagogy fit technology to be integrated and Bloom of Taxonomy levels during assessment that clearly indicate what is expected of learners during the lesson, which reveals a shift in TPACK. Sound lesson planning can be related to strong framing because the learners' activities are clearly considered during technology-integrated lesson planning. As Bernstein (1975p.119) explains, "strong framing/ planning instruction occurs when the teacher clearly explains what needs to be done and how learning will take place". After the workshop, mathematics teachers described their lessons with more visible pedagogic discourses with the intended technology to be integrated. Bernstein, 1975 provides an understanding of pedagogy as the agency not merely of reproduction but of interruption: as the space for thinking the unthinkable, the yet-to-be-thought, and the possibility of new realities.

### 5.2.2 Opportunities are offered or not, to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology.

This research aimed to explore the development of TPACK through the planning of algebra lessons that integrate technology. This was revealed by answering the three research questions mentioned above. Research conducted by Harris et al. (2009;2011) suggested that TPACK can be evaluated through means such as interviews, prepared activities, and lesson plans, as these investigations are more effective in revealing TPACK than TPACK scales, which only measure teachers' thoughts. The preparation of technology-integrated lessons offered mathematics teachers an opportunity to enhance their technological knowledge (TK) and deepen their technological content knowledge (TCK) understanding of how technology could be utilized more effectively to present content in their technology-integrated lessons, as indicated by the finding in chapter 4 section 4.4.3. This finding aligns with Njiku et al. (2021) recommendations that it is not technology alone that can impact their teaching but how teachers utilize it. On the other hand, it should be noted that although most of the mathematics teachers indicated that their TK and TCK have improved, two participants showed in Section 4.4.3 that their CK and PK remained the same.

Furthermore, planning algebra lessons that integrate technology helped mathematics teachers master the skills needed to reach lesson goals TPACK through technological incorporation effectively. Investigating the participants' lesson plans showed that collaborative participation and hands-on learning immensely boosted teachers' understanding and command of TPACK. Aligned with these findings, the study by Lee and Kim (2014) showed that teachers who received guidance in lesson crafting using TPACK displayed enhanced technology competency in teaching compared to those who were not guided by the framework. Moreover, contextual factors, such as learners' classroom behaviours, time, and availability of resources, were found to influence the planning and implementation of technology-integrated lessons.

The findings from the journal reflection and semi-structured interviews revealed that mathematics teachers have learned through recontextualizing as they consider comments and discussions made by peers during workshop activities, made them think and rethink, practising their TK, CK and PK in their context and therefore became aware of many concepts to be considered when planning algebra lesson that integrates technology. As Bernstein (2000) highlighted, the recontextualization process consists of two parts: the curriculum (i.e., the 'what') and the pedagogical approach, which relates to the theory of instruction (i.e., the 'how'). Dickens (2021) referred to recontextualization as inevitable changes to knowledge as it is practised. Therefore, it can be argued that as mathematics teachers practice their TK, PK, and CK during algebra lesson planning, their TPACK was developed. This idea is supported by Harris and Hofer (2019), who posit that as the emphasis is made on whether technology can be selected or avoided, teachers' technological pedagogical content knowledge would be developed authentically and as part of the lesson planning process aligned with curricular standards. This finding is in line with Alemdag et al.'s (2019) study that found that active participation in collaborative, hands-on activities was crucial in developing teachers' technological pedagogical content knowledge.

Mathematics teachers indicated that participating in the workshop focusing on technology integration improved their TPACK development and positively affected their confidence in technology integration. This finding criticizes the findings by the study by Koh (2019) titled: TPACK design scaffolds for supporting teachers' pedagogical change, which assessed TPACK development through pre and post surveys. The study involved 47 teachers and instructors who were attending a graduate course in education technology and found that design scaffolds helped teachers to articulate pedagogic change in their lesson design. However, the current study found that TPACK was developed by recontextualization process through planning lessons that integrate technology. Yet, in this study, contextual factors, such as classroom behaviours, time, and resource availability, were also found to influence the planning and implementation of technology-integrated lessons. Throughout the interviews and analysis of lesson plans, the interplay between technology, pedagogy, and content emerged as a critical factor. This interplay refers to the relationship between how technology is considered to be used, the teaching methods to be employed, and the content being taught. The study highlighted that all types of teacher knowledge are contextually sensitive, and the way technology, pedagogy, and content interact is heavily influenced by the specific teaching context. Moreover, the differences in the findings of the two studies could be because the current study was conducted in the developing countries context, where technologies application and access are not similar.

Hernawati (2019) also noted that addressing challenges related to technology integration requires a contextually sensitive approach. Context can include various elements, such as the culture, learners' behaviours, the school environment, and the learning environment itself. Moreover, some mathematics teachers indicated that the teaching content also shapes how technology, pedagogy, and content come together. They specifically highlighted that planning algebra lessons that integrate technology allowed them to consider critical factors such as the right content, the correct levels of Bloom's Taxonomy, supportive tools and short-coming that may arise during the lesson. However, it can be argued that, considering right content level when using a certain technology after the workshop may indicate a shift in CK while considering supportive tools and technology faults as short-comings indicates a shift in TK.

The interviews, journal reflection and field notes revealed that education context is important in the interplay between technology, pedagogy, and content. The interplay between these three elements can be understood as the relationship between the use of technology, the teaching methods employed, and the content being taught. This finding supports the existing literature arguments that all forms of teacher knowledge are dependent on and sensitive to their specific situations and contexts (Harris & Hofer, 2011; Koehler & Mishra, 2008). However, technology, teaching strategies, and the subject content interact heavily depending on the setting in which they are applied. Here, environment involves factors such as cultural context, student behaviours, school and learning resources, and the distinct factors linked to the learners and the specific educational setting. Furthermore, the subject matter can also weigh the balance between technology, teaching methods, and subject matter, with subjects like mathematics being more well-suited for learning through technology as most mathematics teachers indicated in Section 4.4. that they consider what to teach (content), followed by pedagogy and then the technology that fits the teaching method to be used.

### 5.2.3 Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology

Some of the support needed to develop Technological Pedagogical Content Knowledge when planning algebra lessons that integrate technology discovered in this study concurs with several studies. For instance, this study found that mathematics teachers can be supported to enhance their TPACK through participating in professional development. Participants in this study recommend more continuous professional development workshops targeting lesson planning lessons that integrate technology just to keep up with current trends because technology is continuously changing. Professional development must highlight the importance of Bloom's Taxonomy in technology integration in education. Similarly, the study by Koh, Chai, and Lim's (2017) evaluated the ICT professional development process for developing teachers' technological pedagogical content knowledge for 21st-century learning. The study recommended that Professional Development Content (PD) encourage teachers to create lessons and adopt TPACK principles while incorporating technology and enhancing 21st-century learning. In contrast, Wang (2021) suggested that TPACK professional development should involve online discussions, persuasive arguments, summaries, collaborative projects, synthesizing ideas, and providing options for both synchronous and asynchronous learning.

This study reveals that planning algebra lessons that integrate technology can enhance TPACK development. T1-I in Section 4.4.4 acknowledged that more continuous professional development workshops targeting lesson planning on lessons integrating technology is needed to develop mathematics teachers' Technological Content Knowledge. This finding concurs with the study by Kapici and Akcay (2023) titled: Improving student teachers' TPACK self-efficacy through lesson planning practice in the virtual platform. The study involved 38 undergraduate students in a teacher education program. The findings revealed a significant increase in the TPACK self-efficacy of the pre-service teachers after they designed an inquiry-based technology-enhanced lesson plan on the virtual platform.

In addition, on the support needed by grade 9 mathematics teachers to develop TPACK when planning lessons that integrate technology, Joubert et.al (2020) conducted a Lesson Study (LS) as a form of professional development, with a strong foundation in mathematics education, based on teachers collaborating to design lessons to investigate how LS can be adapted into a blended format to support isolated teachers who cannot meet face-to-face regularly. The study identified eleven aspects playing an essential role in this process, namely technology, group, learning management system; online facilitation; technological pedagogical content knowledge (TPACK); (mobile) learning strategies; a lesson planning form; backward design; time; photos, videos and reports; and reflection questions. This finding is in line with the findings that emerged from the data of this study. Three important aspects to be considered when planning lessons that integrate technology for effective technology integration are supportive tools (i.e., internet, projector, computer, etc.), shortcomings (i.e., weak network, power off, malfunctioning, etc.) and levels of Bloom taxonomy for the content (remembering, understanding, application, analysis, synthesis and create). However, other studies have also identified short comings and referred to these concepts as constraints. The expected constraints, as reported in previous studies, include teacher resistance (du Plessis & Webb, 2012), poor connectivity (Rabah, 2015; Eshetu, 2015 & Young, 2016), and electricity outages (Elemam, 2016 & Ngoungouo, 2017). Common barriers to ICT use are usually a lack of resources or Internet access and lack of funding for projects with power failures, poor network coverage, and the negative impact ICTs have on learner discipline coming in at a close second (Padayachee, 2017). However, this study highlights that these barriers could be mitigated by planning for technology integration because one could borrow pocket WIFI or power back-ups.

In addition, technical support was discovered in this study as the support needed by Grade 9 mathematics teachers to develop TPACK when planning lessons that integrate technology. Mathematics teachers suggested that the government offer technical support to schools because some schools' computers have outdated hardware and software programs, bringing several technical faults. The support should include online community support access to a range of digital resources such as up-to-date educational websites and online databases that align with the curriculum and suitable level of Bloom's Taxonomy. Technical support was also revealed in Kock's study (2022). The study aimed to explore and understand the extent to which implementing the WCED Model School Initiative (MSI) improved teachers' technological knowledge and skills to use technology for teaching and learning. The study confirmed that "technical support also empowers and professionally develops teachers as they are trained to perform these tasks themselves" (p.78).

### 5.3 Summary of the chapter

This chapter intended to present findings pertaining to exploring Grade 9 mathematics teachers' development of technological pedagogical content knowledge when planning algebra lessons that integrate technology. The data were drawn from the generated qualitative data discussed in line with this study's theoretical framework and literature review. In addition, the findings from Chapter Four were discussed based on 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 mathematics teachers enhanced their TPACK constructs through planning algebra lessons that integrate technology. The next and final chapter presents the study’s conclusions and recommendations of this study and also provides suggestions for further studies.

# Chapter Six: Conclusion and Recommendations

6.1 • Introduction
6.2 • Summary of the study
6.3 • Overview of the study
6.4 • Summary of key research findings
6.5 • Limitations of the study
6.6 • Summary of the study's findings
6.7 • Recommendations for practice
6.8 Recommendations for further studies
6.9 • Summary of the chapter

## 6.1 Introduction

This final 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.

## 6.2 Summary of the study

This study sought to explore Grade 9 mathematics teachers' TPACK development through planning algebra lessons integrating technology in the Oshakati education circuit. To achieve this goal, the following research questions were posed:

1. In what ways do Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology in the Oshakati education circuit?
2. What opportunities are offered or not, to Grade 9 mathematics to develop TPACK when planning algebra lessons that integrate technology in the Oshakati education circuit?
3. How can Grade 9 mathematics teachers be supported in developing technological pedagogical content knowledge when planning algebra lessons that integrate technology?

The study was designed as qualitative research using a single case study approach. The choice of a research design is important to establish the boundaries of inquiry and the ultimate success of a study. A purposive sampling method was used to select ten mathematics teachers from four secondary schools in the Oshakati education circuit. The criteria for choosing the research sites and participants were sufficiently explained. This study employed the following research instruments: demographic open-ended questionnaires, workshop discussions, field notes, document analysis, journal reflections, semi-structured interviews, and focus group interviews. The study was guided by the constructs of Bernstein's (1971) sociology of education theory, Bloom's (1956) Bloom's Taxonomy theory and Mishra and Koehler's (2006) Technological, Pedagogical, Content Knowledge (TPACK) as theoretical and an analytical framework, respectively. The choice of using these theories in this study was explained and justified. Data were thematically analyzed, and the emerging themes were noted.

### 6.3 Summary of key research findings

The key findings for this study are presented in relation to the research questions and the themes that emerged during data analysis.

#### 6.3.1 Grade 9 mathematics teachers describe their process in planning algebra lessons that integrate technology.

Before the intervention, most mathematics teachers indicated that they have access to, and use various technologies for different purposes. The findings further show that mathematics teachers have a positive perspective on using technology in teaching. However, they do not plan for lessons that integrate technology. The finding revealed that mathematics teachers possessed TK and CK at some points before participating in the workshop but did not possess TPACK, which was defined by Mishra and Koehler (2009) as knowledge required for successful technology integration. The way mathematics teachers described their process in planning lessons that integrate technology, before the intervention, according to Bernstein (1975), is regarded as invisible or weak framing because their lessons description indicated no clear activities for learners as a result learner's power or authority was moderate. When pedagogy is invisible, the teacher arranges the lesson without clear activities for learners (Bernstein, 1971). So, within this context, the learner has more power over what he/she selects, over how he/she structures, and over the time scale, including his activities. However, after the intervention, mathematics teachers described their lessons indicating moderate teacher influence on knowledge selection which made their lesson plans moving from $F^-$/weak framing to $F^+$/strong framing.

Furthermore, the cause of some mathematics teachers believing to have TPACK could be because some mathematic teachers did not differentiate between TK and TPACK when they defined the two constructs before participating in the workshop. This finding implies that mathematics teachers could find it difficult to plan lessons integrating technology because they do not understand TPACK before the workshop. Understanding TPACK among teachers can provide a coherent structure that allows them a better understanding of sound planning of lessons that integrate technology. Teachers with useful technology integration make practical decisions regarding learning content, teaching goals, and pedagogical methods and assess the lesson outcomes (Henriksen et al., 2016).

The results from document analysis evaluation of the lesson plans that mathematics teachers submitted after the workshop as triangulated with findings from the semi-structured interviews and journal reflection, and they yielded relevant findings. The results show that nearly half of the participants were advanced and proficient in TPACK constructs, scoring 100% on their lesson plans TPACK assessment. The document analysis results show that the lesson planning workshop has improved the mathematics teachers' understanding of the TPACK framework rather than what mathematics teachers reported during the interviews. The results also demonstrate how mathematics teachers' knowledge of TPK, TCK, and PCK are interrelated to form TPACK, and this points to how a teacher's descriptions of their planned lessons that integrate technology influenced by TPACK align with their intention in planning instruction that integrates technology.

Furthermore, the findings of this study on how mathematics teachers describe algebra lesson plans that integrate technology indicate that mathematics teachers have improved the description of their lessons after the intervention than before. The findings revealed that mathematics teachers planning lessons that integrate technology after the interventions considered the relationship among content, pedagogy, and technology as they describe their lesson in more detail than before. After participating in the workshop, mathematic teachers considered other factors in their real context such as supportive tools, short-coming and improvision. They also considered content in detail as to how the content and pedagogy fits technology to be integrated as well as Blooms of Taxonomy levels during assessment that clearly indicate what is expected of learners during the lesson. Considering the right taxonomy level reveals good Content Knowledge (CK). This can be defined as strong framing because the learners' activities are clearly considered during lesson planning. Bernstein (1975, p.119) explains that "strong framing/ planning. instruction occurs when the teacher clearly explains what needs to be done and how learning will occur". After the workshop, mathematics teachers described their lessons with more visible pedagogic discourses with the intended technology to be integrated, showing advanced TPACK knowledge.

### 6.3.2 Opportunities offered or not, to Grade 9 secondary school mathematics to develop TPACK when planning algebra lessons that integrate technology.

The preparation of technology-integrated lessons offered mathematics teachers an opportunity to consider critical factors such as the right Bloom's Taxonomy level for the content to be taught, how the technology available fits the content and pedagogy, supportive tools and shortcoming that may arise during the lesson. This practice enhanced their technological knowledge (TK) and deepened their understanding of how technology could be utilized more effectively to present content in their technology-integrated lessons (TCK). The key finding that emerged is that planning algebra lessons that integrate technology offered mathematics teachers an opportunity to practice their TK, PK and CK during algebra lesson planning, resulting in their TPACK being developed through recontextualizing. The comments and critics from other participants during the workshop have allowed them to think and re-think on how various technology can afford or constraint the achievements of their mathematics lessons.

The empirical findings from this study are that the development of TPACK during lesson planning is not through social interaction as revealed by previous researchers, Alemdag et al.,2019; Kafyulilo et al., 2015; Kay, 20017; Shambare, 2021). However, during planning lessons that integrate technology, TPACK is developed through the process of recontextualization (Bernstein 1975). As decision is made whether technology will be integrated or not TPACK is developed authentically. Additionally, mathematics teachers have learned through recontextualizing as they consider comments and suggestions made by peers during the workshop activities, made them think and rethink, pracitising their TK, CK and PK within their context and therefore became aware of many concepts to be considered when planning algebra lesson that integrates technology.

As Bernstein (2000) highlighted, the recontextualization process consists of two parts: the curriculum (i.e., the 'what') and the pedagogical approach, which relates to the theory of instruction (i.e., the 'how'). By framing the lesson that integrate technology, mathematics teachers practiced their CK, PK and TC, prompting them to consider other factors that lies within their context. In addition, this study revealed the deference between planning lessons that integrate technology, in a developing country's context, which regards to how the technology is intended to be utilized to achieve the goals of the lesson and the lesson design which is to design lesson activities using technologies. Technology integrated lesson planning fits well in developing countries while technology integrated lesson design fits well in most developed countries where technology utilization is at advance level.

### 6.3.3 Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology

When exploring how can the Grade 9 mathematic teachers be supported to develop technological pedagogical content knowledge when planning algebra lessons that integrate technology, several factors were noted. This study found that mathematics teachers can be supported to enhance their TPACK through participating in more continuously professional development workshops targeting lesson planning lessons that integrate technology just to keep up with what is current because technology is continuously changing. Professional development must highlight Bloom's Taxonomy's importance in technology integration education. The workshop should not provide a mere technological knowledge but should seek to balance between technology, pedagogy and content knowledge.

The study reveals that the government should offer technical support to schools because some schools' computers have outdated hardware and software programs, and this brings several technical faults. The support should include online community support access to a range of digital resources such as date educational websites and online databases resources that align with the curriculum and suitable level of Bloom's Taxonomy. Mathematics teaches need to have access to various digital resources such as up-to-date educational websites and online databases. Mathematics teachers urge the Ministry of Education to provide support in terms of resources that align with the curriculum and suitable level of Bloom's Taxonomy. Supports include technical support such as troubleshooting and online community forums. Mathematics teachers further, recommend to continue conducting lesson planning workshops even after the study ends. They highlighted that it is important for their professional development.

The current study has contributed to the research about developing TPACK when planning lessons that integrate technology. The findings of this research have given more attention to encouraging mathematics teachers to plan for technology-integrated lessons, boosting teachers' confidence in successful technology integration, and improving the teaching and learning of mathematics education.

### 6.4 Limitations of the study

While a lot of care and rigour were applied in the preparation and conduct of the study, there are limitations which the reader should acknowledge.

- The sample size used in the study was adequate. However, because purposive or convenience sampling was used instead of random sampling, the result cannot be generalized to all schools in the country (it was limited to ten mathematics teachers and four schools).
- Moreover, this study was conducted in a resource-constrained developing country context. Therefore, the findings of this study cannot be generalized to resource-privileged schools.
- This study's findings provide a limited perspective on the development of TPACK for teaching mathematics with technology. Additionally, the findings indicate that teachers acquired TPACK related to technology integration in lessons but the study does not incorporate the teachers' own reflective input following their lessons on technology integration in the classroom.
- This study was conducted within a limited timeframe. I recommend that future researchers undertake a longitudinal study to monitor the progression of TPACK in teachers over an extended duration. This could yield invaluable insights into the factors shaping the evolution of TPACK and its long-term impact on teaching practices.

### 6.5 Recommendations for Practice

Premised on the findings of this study, the researcher wishes to make the following recommendations:

- The study recommends that in-service mathematics teachers partake in continuous professional development workshops aimed at weaving technology into lesson preparation to augment their expertise in technology integration into classrooms.
- Technical support is needed for the successful integration of technological tools into teaching and learning processes. Policymakers must provide support that enhances technology integration, such as ICT policies, incentives, and resources.
- Encourage collaborative learning and sharing of best practices among teachers. They can learn a lot from each other's experiences and effective TPACK development strategies. As identified in this study, social interactions among teachers play an

instrumental role in enhancing TPACK development. Teachers can learn from each other, and share practical experiences and innovative strategies about integrating technology into mathematics instruction.

- Teachers should constantly self-reflect on their TPACK skills and adapt their teaching practices accordingly. They should critically assess how well they are integrating technology into their classes and whether their pedagogical strategies are effectively utilizing the available technology.

### 6.6 New Knowledge Contribution by the Study

The study makes a significant contribution to the existing body of knowledge on TPACK development. By adopting Bernstein's theory, the study revealed that during lesson planning TPACK can be developed through the process of recontextualization rather than social interactions. Developing TPACK through contextualization is important in developing countries like Namibia where teachers' technological knowledge is at the basic level. The study focus on the contextualized development of TPACK among Grade 9 mathematics teachers in Namibia also highlights the importance of curriculum relevance in TPACK development.

The study recognizes that TPACK development is not a one-size-fits-all approach and that it is essential to consider the specific constraints and opportunities faced by teachers in a particular educational context. The study recognizes that the integration of technology in mathematics education is not a straightforward process and that it is essential to consider local factors such as access to technology, infrastructure, and cultural factors that may impact the integration of technology in teaching and learning.

### 6.7 Recommendations for further studies,

- Technology integration is an emerging teaching approach that is growing gradually with a lot of potential in the field of education. This study explored only the development of TPACK through lesson planning. This opens the opportunity for further research to examine the development of TPACK during the implementation of the lesson plan into teaching practices.
- In addition, this research was designed as qualitative. Future research could employ a mixed-method approach involving both qualitative and quantitative designs. The quantitative design aspect would help to better quantify mathematics teachers' TPACK levels achievements on their lesson plans in terms of analyzing performance

in pre-tests and post-tests. Therefore, it is recommended that further research be exercised to empirically determine if planning lessons that integrate technology impact TPACK development.

- The theoretical framework used in this study has rarely been used in studies related to technological pedagogical content knowledge. This provides a platform for greater exploration pertaining to the development of TPACK that has not yet been fully explored. These are the development of the curriculum-based TPACK and visible pedagogy supporting subject policies.

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# APPENDICES

## APPENDIX A: RHODES CLEARANCE CERTIFICATE

RHODES UNIVERSITY
*Where leaders learn*

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

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

26 January 2023

Dr Clement Simuja

Education Department

C.Simuja@ru.ac.za

Dear Dr Clement Simuja and Ms Mechtilde Angula

**Re:** Exploring Secondary Schools Mathematic teachers' TPACK development through planning lessons that integrate technology in Namibia

APPLICATION NUMBER: 2023-7001-7378

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) where applicable have been received and you are free to proceed with your study.

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

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

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

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

Sincerely,

E Rosenberg

**Prof Eureta Rosenberg**

**Chair: Education Faculty Research Ethics Committee**

Page 1 of 1

# APPENDIX B: APPROVAL LETTER FROM OSHANA DIRECTORATEOF EDUCATION

REPUBLIC OF NAMIBIA

**OSHANA REGIONAL COUNCIL**
**DIRECTORATE OF EDUCATION, ARTS AND CULTURE**
*ASPIRING TO EXCELLENCE IN EDUCATION FOR ALL*

*Tel: 065 - 229800/25*
*Fax: 065 - 229834*
*Enquiries: Hileni M Amukana*
*Ref. 13/2/9/1*

*Private Bag 5518*
*Oshakati*

Ms. Mechtilde Angula
P. O. Box 7253
Oshakati

Cell: 0813127029

**SUBJECT: PERMISSION TO CONDUCT A RESEARCH IN OSHANA REGION**

Your letter dated 23 January 2023 on the above caption bears reference.

Kindly be informed that permission is hereby granted to conduct research study from Schools and Teachers in Oshakati Circuit, Oshana Region.

**Research topic:** **Exploring Secondary Schools Mathematic Teachers' TPACK development through planning of algebra lessons that integrate technology in Namibia.**

This permission is subject to the following strict conditions; **(i)** There should be minimal or no interruption on normal working schedule **(ii)** Ethical issues of confidentiality and anonymity should be respected and retained throughout this activity i.e. Voluntary participation, and consent from participants

Both Parties should understand that this permission could be revoked without explanation at any time.

Furthermore, we humbly request you to share your research findings with the Directorate of Education, Arts and Culture, Oshana Region. You may contact Ms. Hilma Nuunyango-George, the Deputy Director; Programs and Quality Assurance (PQA) for the provision of summary of your research findings.

We wish you the best in conducting your study.

Yours sincerely,

01.02.2023

**HILENI M. AMUKANA**
**REGIONAL DIRECTOR**

OSHANA REGIONAL COUNCIL DIRECTORATE OF EDUCATION, ARTS & CULTURE OFFICE OF THE DIRECTOR
01 FEB 2023
Private Bag 5518
OSHAKATI
REPUBLIC OF NAMIBIA

Cc: *Inspector of Education: Oshakati Circuit*

*All Official Correspondence must be addressed to the Regional Director*

# APPENDIX C: CONSENT FORMS SAMPLE

... will be used for academic ... there is no penalty for non-participation. Being in this study you are under no obligation to consent to participation. You are free to withdraw at any time and without giving a reason; however, it is important to note that it will not be possible to withdraw the questionnaire once you have submitted it. Your help would be greatly appreciated. Thank you very much for your time and cooperation.

The following institutions have approved this research: the Rhodes University Ethical Standards Committee, the Rhodes University Education Department Higher Degrees Committee, and The Eastern Cape Department of Education. During the research, any concerns may be directed to Rhodes University ethics committee, ethics-committee@ru.ac.za and Dr C. Simuja (Supervisor), c.simuja@ru.ac.za.

Warmest regards,

[signature]

Mechtilde Angula

CONSENT: I AM AWARE THAT

- I will be a respondent for the above-mentioned topic.
- 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 and 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 volunteer to participate in the research process and acknowledge that I have not been forced to do so.
- I am aware that COVID-19 regulations will be adhered to.

DECLARATION

I Aveshe Simataa (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.

Participant's Signature: [signature] Date: 24/02/2023

Researcher's Signature: ____________ Date: ____________

## Appendix D: DEMOGRAPHIC OPEN-ENDED QUESTIONNAIRE

Date: __________________ ***for any question feel free to call: 0813127029***

Phone: ________________

Email: _________________

**Introduction**

This MEd questionnaire is designed to obtain your views on **Promoting Grade 9 mathematic teachers' TPACK development through planning algebra lessons that integrate technology.** Kindly be open and be free to answer questions far 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.

**Instructions**

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. Mark with **X** 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:** DEMOGRAPHIC INFORMATION

(Please check √ only one option for each statement below)

1. How do you currently describe your gender identity?

| | |
|---|---|
| Female | |
| Male | |
| Other | |
| Prefer not to answer | |

2. What is your age?

| | | | |
|---|---|---|---|
| 21 and below | | 41-50 | |

| | | | |
|---|---|---|---|
| 22-30 | | 51-60 | |
| 31-40 | | 61 and over | |

3. What grade(s) do you teach? Please select all that apply.

| | |
|---|---|
| 7 | |
| 8 | |
| 9 | |

4. What is your current teaching experience?

| | | | |
|---|---|---|---|
| 0-4 | | 16-20 | |
| 5-10 | | 21-25 | |
| 11-15 | | 26 or more years | |

5. What is the highest level of education you have completed?

| | | | |
|---|---|---|---|
| Grade | | Master's Degree | |
| Bachelor's Degree | | Doctoral Degree (PhD, EdD) | |
| Post-Graduate Certificate | | Other | |

6. Which degree(s)/Certificates(s) do you have? Please select all that apply.

| | | | |
|---|---|---|---|
| Bachelor of Education | | Master of Education | |
| Bachelor of Science | | Master of Science | |
| Post-Graduate Certificate | | Other | |

**SECTION B: TECHNOLOGY ACCESS AND USE**

(Please check √ only one answer)

| | <1hr | 1hr | 2-3hrs | 4-6hrs | 7+hrs |
|---|---|---|---|---|---|
| 7. How many hours a day do you spend on a computer /laptop/tablet/cell-mobile phone for teaching purposes? | | | | | |
| 8. How many hours a day do you spend on a computer /laptop/tablet/cell-mobile phone for personal purposes? | | | | | |
| 9.. How many hours a day do you use the internet for study purposes? (e.g., Blackboard, Google Scholar, Educational sites, etc.) | | | | | |
| 10. How many hours a day do you use the internet for personal purposes? (Such as Facebook, online shopping; YouTube; WhatsApp; etc.) | | | | | |

11. Describe your technology use in mathematics

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

**SECTION C: MATHEMATICS TEACHERS' UNDERSTANDING OF TPACK**

(Please check √ only one answer)

12. DEFINE TECHNOLOGICAL KNOWLEDGE:

……………………………………………………………..……………………………………

……………………………………………………………………………………………….…

……………………………………………………………………………………...……..

| **Item No and TPACK** | **Perceptions about TPACK constructs** | Agree | Neutral | Disagree |
|---|---|---|---|---|
| 13. TK | I have advanced technological knowledge for planning technology-integrated lesson | | | |

| | | | | |
|---|---|---|---|---|
| 14. CK | I have advanced content knowledge of algebra | | | |
| 15. PK | I have advanced pedagogical knowledge to teach algebra | | | |
| 16. PCK | I have advanced pedagogical content knowledge to teach algebra | | | |
| 17. TCK | I have advanced technological content knowledge for planning technology-integrated lesson | | | |
| 18. TPK | I have advanced technological pedagogical knowledge for planning technology-integrated lesson | | | |
| 19. TPACK | I have advanced technological pedagogical content knowledge for planning technology-integrated lesson | | | |

20. Define technological pedagogical knowledge:

…………………………………………………………………………………………

…………………………………………………………………………………………

21. Describe your planning of lessons that integrate technology in mathematics lessons

…………………………………………………………………………………………

…………………………………………………………………………………………

**Appendix E**

## Journal Reflection on daily activities

**Instruction: Please reflect on the following points**

1. Briefly outline on what you have you learned so far from your participation in the study.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Reflect on any contextual information (e.g.) access to a computer lab, materials and resources available; particular departmental/school-wide initiatives) that influenced the design of your lesson.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

2. Please reflect on what you consider when planning an assessment activity for the Grade 9 algebra lesson that integrate technology.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

3. Please give a review about what determines the choice of the technology that you integrate into planning of your Grade 9 algebra lesson activities.

…………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

4. Think about TPACK constructs that informed your Grade 9 algebra lesson plan before and after the intervention. Do you think they remain the same?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………….

THE END

## Appendix F: Semi-Structured Interview and Focus Group Interviews

Describe Planning of Grade 9 algebra lessons that integrates technology

1. What technologies (digital) do you plan to use in algebra lesson? Where, how and when do you want your learners to use them?

2. Describe any contextual information (e.g. access to a computer lab, materials and resources available, particular departmental/school-wide initiatives) that influenced the design or implementation of algebra lesson activities.

3. Describe the learners' learning goals/objectives planned and assessment in algebra lessons that integrate technology. (These will not necessarily be state or national standards. Participants should describe these in their own words.

4. How and why do the particular technologies to be used in algebra lessons "fit" the instructional strategies you intend to use and content?

5. Do you start with technology, pedagogy, content or some combination when planning algebra lesson? In what order do you consider these components in your planning?

6. How useful was planning of algebra lessons that integrate technology to developing your TPACK?
7. What type of future support would you need in order to continue technology integration in your lessons planning?

**Appendix G: Document Analysis Guide (Rubric), adapted from Harris, Grandgenett, & Hofer, (2010)**

| Criteria | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Curriculum Goals & Technologies** (Curriculum-based technology use) | Technologies selected for use in The instructional plan are strongly aligned with one or more curriculum goals. | Technologies selected for use in The instructional plan are aligned with one or more curriculum goals. | Technologies selected for use in The instructional plan are partially aligned with one or more curriculum goals. | Technologies selected for use in the instructional plan are not aligned with any curriculum goals. |
| **Instructional Strategies & Technologies** (Using technology in teaching/ learning) | Technology use Optimally Supports Instructional strategies. | Technology use Supports Instructional strategies. | Technology use Minimally Supports Instructional strategies. | Technology use does not support Instructional strategies. |
| **Technology Selection(s)** (Compati Bility with curriculum Goals & instructional strategies) | Technology selection(s) are exemplary, given curriculum goal(s) and instructional strategies. | Technology selection(s) are appropriate, but not exemplary, given curriculum goal(s) and instructional strategies. | Technology selection(s) are marginally appropriate, given curriculum goal(s) and instructional strategies. | Technology selection(s) are inappropriate, given curriculum goal(s) and instructional strategies. |
| **"Fit"** (Content, pedagogy and technology together) | Content, Instructional strategies and technology fit | Content, Instructional strategies and technology fit | Content, Instructional strategies and technology fit | Content, Instructional strategies and technology do not |

| | | | | |
|---|---|---|---|---|
| | together strongly within the instructional plan. | together within the instructional plan. | Together somewhat within the instructional plan. | fit together within the instructional plan. |