

**EVOLUTION OF INSTRUCTORS' TECHNOLOGICAL PEDAGOGICAL CONTENT
KNOWLEDGE IN VOCATIONAL TRAINING CENTRES: MULTI-CASE STUDY**

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with the requirements for the degree of**

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BY

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DECLARATION

I, Victoria Nepembe (g17s8822), affirm that the dissertation entitled, **Evolution of Instructors' TPACK in Vocational Training Centres: A Multi-Case Study**, presented for the attainment of the Doctor of Philosophy (ICT in Education) degree at Rhodes University, is the result of my individual effort.

I have duly acknowledged and referenced all sources consulted in this work.

In addition, I confirm that this thesis has not been previously submitted for a qualification at any other university or faculty.



10 January 2025

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ABSTRACT

Technologies are now prevalent in society and vocational classrooms, with an increasing belief that educational technology can transform vocational education. In developing countries like Namibia, instructors (teachers in vocational schools) face significant responsibility for developing and enhance their technology knowledge for teaching and and learning. Literature suggests that in vocational education, where technology has a substantial impact, integrating technology into teaching and learning is key to achieving educational objectives. Instructors need to develop Technological Pedagogical Content Knowledge (TPACK) to effectively integrate technology in teaching. To support this integration, Namibia's Ministry of Education introduced a national policy for information and communications technology (ICT) in education in 2005, alongside initiatives like the International Computer Driving License, the Education and Training Sector Improvement Programme, and the Tech/NA! ICT Implementation Plan. Instructors attend workshops to enhance their technological skills. This study aimed to explore how instructors develop their ability to teach with technology to support meaningful integration in vocational education. The study employed a qualitative multi-case design within the interpretive paradigm, guided by the TPACK framework and Self-Directed Learning theory. The study included 25 participants selected through criterion sampling from Vocational Education and Training (VET) institutions nationwide, based on their teaching levels, access to technology, and willingness to engage in various research methods (interviews, observations, and focus group discussions). Out of these participants, six indicated their willingness to participate further in semi-structured interviews, non-participatory observations, and focus group discussions. Thematic analysis was conducted with the assistance of NVivo software (version 22) to code the data, identify patterns, and develop themes and sub-themes. The study revealed limited understanding of TPACK among educators and Technical Vocational Education and Training (TVET) teachers engaged in self-initiated learning to integrate technology without formal guidelines, demonstrating awareness of their knowledge development. Despite challenges such as inadequate technological infrastructure, insufficient training, unstable internet, and limited access to technologies, TVET teachers actively pursued self-directed learning efforts to integrate technologies that enable them to develop TPACK. Most teachers showed strength in content knowledge (CK) developed through their pre-service training, while technology-related workshops motivated them to enhance their pedagogical knowledge and technological knowledge. Teachers use online

sources, YouTube lessons, and peer learning communities to improve pedagogical and technological knowledge, which also contributes to their development of pedagogical content, technology pedagogical and technology content knowledge and TPACK. The study proposes the Contextual - TPACK (C-TPACK) framework as an expanded model tailored to TVET teachers for effective technology integration in Namibia. It also suggests revising professional development programmes, increasing investment in technological infrastructure, and fostering collaboration among teachers, students, and external partners.

Keywords: digital technology, teaching and learning, instructors, Technical Vocational Education and Training centres, TPACK, self-directed learning

LIST OF PUBLICATIONS

JOURNAL ARTICLE	AUTHORS	JOURNAL	YEAR OF PUBLICATION
Instructors' perspectives of TPACK in a vocational training classroom in Namibia	Victoria Nepembe & Clement Simuja	Journal of Vocational, Adult and Continuing Education and Training	2023

DEDICATION

This thesis is dedicated to my mother *Maria Kleopas Mupetami* for nurturing and teaching me to be a responsible child, and for her unstoppable prayers and wisdom. My nieces: *Paulina Shigwedha; Lea Indongo; Esther Uugwanga; Josephine Shigwedha* and nephews: *Ronny Richard Shigwedha and Max Kandjembo Shigwedha* for taking over parental duty in my absence due to a busy schedule with schoolwork. My late nephew *Natangwe Ndangi Nangula*; May his soul rest in peace.

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TABLE OF CONTENTS

ABSTRACT	iii
LIST OF PUBLICATIONS	v
DEDICATION.....	vi
ACKNOWLEDGEMENTS	vii
LIST OF FIGURES	xv
LIST OF TABLES	xvi
LIST OF ABBREVIATIONS AND ACRONYMS	xvii
1 CHAPTER ONE	1
INTRODUCTION AND BACKGROUND.....	1
1.1 Introduction.....	1
1.2 Background and Context of the Study	1
1.3 Statement of the Problem.....	7
1.4 Significance of the Study	9
1.5 Research Objectives.....	11
1.6 Research Questions.....	11
1.7 Research Methodology	11
1.8 Definition of Terms.....	12
1.9 Structure of the Thesis	13
1.10 Chapter Summary	14
CHAPTER TWO	15
2 LITERATURE REVIEW	15
2.1 Introduction.....	15
2.2 The term “Instructor”	17
2.3 An Overview of Vocational Education and Training (VET).....	18

2.4	Integration of Technology into Teaching and Learning in VET	20
2.5	Integration of Technology into Teaching and Learning in Other Contexts	28
2.6	Barriers to Technology Integration into Teaching and Learning in VET	30
2.7	Technological Pedagogical Content Knowledge in Teaching and Learning	34
2.8	TPACK Development of Teachers in Teaching and Learning	38
2.9	Knowledge gaps in the Reviewed Literature	42
2.10	Chapter Summary	44
CHAPTER THREE		46
3	THEORETICAL FRAMEWORK.....	46
3.1	Introduction.....	46
3.2	Theoretical Frameworks	47
3.2.1	TPACK framework.....	47
3.2.1.1	Shortcomings of the TPACK framework in this study.....	50
3.2.2	Self-directed learning theory.....	51
3.2.1.2	Autonomy	55
3.2.1.3	Self-motivation	56
3.2.1.4	Prior experiences	57
3.2.1.5	Resources availability.....	57
3.2.3	Justification for the adoption of the SDL theory	58
3.2.4	Shortcomings of the SDL theory	59
3.3	Combination of the TPACK Framework and the SDL Theory	60
3.4	Chapter Summary	63
CHAPTER FOUR.....		64
4	RESEARCH METHODOLOGY.....	64
4.1	Introduction.....	64
4.2	Research Paradigm.....	65

4.2.1	The positivist paradigm.....	66
4.2.2	The post-positivist paradigm.....	66
4.2.3	A critical or transformative paradigm.....	66
4.2.4	The pragmatic paradigm	67
4.2.5	The interpretivist paradigm.....	67
4.2.5.1	Ontology	68
4.2.5.2	Epistemology	68
4.2.5.3	Methodology	69
4.2.5.4	Axiology	69
4.3	Research Approach	69
4.3.1	Multiple cases	70
4.4	Research Design.....	71
4.5	Research Site.....	71
4.6	Selection of Participants	72
4.7	Sampling	73
4.8	The Research Process	73
4.8.1	Exploratory phase	75
4.8.1.1	Questionnaire.....	75
4.8.1.2	Semi-structured interviews	76
4.8.1.3	Focus group discussions	76
4.8.1.4	Non-participatory observation.....	77
4.8.2	Reflective workshop phase	78
4.9	Positionality and Reflexivity.....	80
4.10	Data Analysis	82
4.10.1	Data analysis in the exploratory phase	82
4.11	Validity, Reliability, and Trustworthiness	86

4.11.1	Validity	86
4.11.2	Reliability.....	86
4.11.3	Trustworthiness	86
4.12	Ethical Considerations	87
4.12.1	Ethical clearance and gatekeeper permission	87
4.12.2	Informed consent and voluntary participation.....	88
4.12.3	Confidentiality, privacy, and anonymity	88
4.12.4	Integrity, respect, honesty, and transparency	88
4.12.5	Feedback to the participants	88
4.13	Chapter Summary	89
5	CHAPTER FIVE	90
	PRESENTATION AND ANALYSIS OF RESULTS	90
5.1	Introduction.....	90
5.2	Personal encounter with the participants.....	91
5.3	Data Presentation from the Questionnaire	92
5.3.1	Biographic characteristics of participants.....	92
5.3.1.1	Participants gender	94
5.3.1.2	Participants' ages	94
5.3.1.3	Participants' race.....	95
5.3.1.4	Discipline taught in VET institutions of the selected participants.....	95
5.3.1.5	The participants' teaching levels in VET qualifications	96
5.3.1.6	Participants' teaching experience	96
5.3.1.7	Participants' level of education.....	97
5.3.2	Participants' access and use of technology in the classroom.....	97
5.3.3	TVET teachers' understanding of TPACK.....	100
5.3.4	TPACK and technology integration in VET.....	101

5.3.4.1 Content Knowledge	103
5.3.4.2 Pedagogical Knowledge.....	103
5.3.4.3 Technological Knowledge	103
5.3.4.4 Pedagogical Content Knowledge.....	104
5.3.4.5 Technological Pedagogical Knowledge.....	104
5.3.4.6 Technological Content Knowledge.....	105
5.3.4.7 Technological Pedagogical Content Knowledge	105
5.3.5 Findings from semi-structured interviews and classroom observations	106
5.3.5.1 Shilongo's case study.....	106
5.3.5.2 Ndangi's case study	126
5.3.5.3 Angula's case study	145
5.3.1.4 Iyaloo's case study.....	162
5.3.5.5 Nadhipite's case study	176
5.3.5.6 Iyambo's case study	192
5.4 Findings From the Focus Group Discussion.....	211
5.4.1 Technologies for teaching.....	211
5.4.2 Sources of TPACK	212
5.4.3 Challenges experienced when teaching using technology.....	214
5.4.4 Support needed to integrate technology into teaching.....	217
5.5 Chapter Summary	218
CHAPTER SIX	219
6 DISCUSSIONS OF FINDINGS	219
6.1 Introduction.....	219
6.2 The Approach in This Study	219
6.3 Key Findings from the Study	220
6.3.1 The individual understanding and shifting of TPACK understanding	221

6.3.2	Individual self-initiated learning activities and TPACK development.....	231
6.3.2.1	Content Knowledge	232
6.3.2.2	Pedagogical Knowledge.....	235
6.3.2.3	Technological Knowledge	236
6.3.2.4	Technological Pedagogical Knowledge.....	242
6.3.2.5	Technological Pedagogical Content Knowledge	242
6.3.3	Drivers and constraints for integration and use of technology in teaching...	243
6.3.4	Harmonising the support that initiates self-TPACK development	245
6.4	Proposing a New TPACK Framework for the VET Teachers.....	246
6.4.1	TPACK development in the VET context	248
6.4.2	TPACK development among TVET teachers.....	249
6.4.3	Implications of the proposed C-TPACK model in VET centres	250
6.5	Summary of the Chapter	251
CHAPTER SEVEN.....		253
7	SUMMARY OF FINDINGS, RECOMMENDATIONS, AND CONCLUSION	253
7.1	Introduction.....	253
7.2	Summary of the Findings.....	253
7.2.1	The individual understanding and shifting of TPACK understanding	253
7.2.2	Individual self-initiated learning activities and TPACK development.....	254
7.2.3	Drivers and constraints for integration of technology into teaching and learning	256
7.2.4	Harmonising the support that initiates self-TPACK development	256
7.3	Development of New Knowledge in TVET	259
7.3.1	Theoretical contributions	260
7.3.2	Methodological contributions	262
7.4	Implications and Recommendations for Practice and Further Research	265

7.4.1	Implications for practice	265
7.4.1.1	TVET teachers.....	265
7.4.1.2	Heads of centres.....	266
7.4.1.3	Policymakers	267
7.4.1.4	TVET teachers training institutions.....	268
7.4.1.5	Global applicability of the study's recommendations.....	269
7.4.1.6	Enhancing professional TVET teachers' development	269
7.4.1.7	Infrastructure and resource allocation	270
7.4.2	Recommendations for future research	270
7.5	Limitations of the Study.....	271
7.6	Major Conclusion of the Study and Reflections	273
REFERENCES.....		276
8	APPENDICES.....	325
APPENDIX A: LETTER TO NAMIBIA TRAINING AUTHORITY		325
APPENDIX B: LETTER TO NAMIBIA COLLEGE OF OPEN LEARNING		326
APPENDIX C: LETTER TO WINDHOEK VOCATIONAL TRAINING CENTRE		327
APPENDIX D: QUESTIONNAIRE TOOL		328
APPENDIX E: SEMI-STRUCTURED INTERVIEW TOOL.....		332
APPENDIX F: TPACK LESSON OBSERVATION SCHEDULE		335
APPENDIX G: FOCUS GROUP DISCUSSION GUIDE.....		337
APPENDIX H: RHODES UNIVERSITY ETHICS CLEARANCE		340
APPENDIX I: RHODES UNIVERSITY HIGHER DEGREE APPROVAL.....		341
APPENDIX J: NTA PERMISSION LETTER TO CONDUCT RESEARCH		342
APPENDIX K: NAMCOL PERMISSION LETTER TO CONDUCT RESEARCH.....		343
APPENDIX L: WVTC PERMISSION LETTER TO CONDUCT RESEARCH.....		344
APPENDIX M: CERTIFICATE OF LANGUAGE EDITING		345

LIST OF FIGURES

Figure 3.1: The TPACK framework	48
Figure 4.1: The VET centres.....	72
Figure 4.2: The research process	74
Figure 4.3: Data analysis process.....	83
Figure 5.1: Technology use frequency in teaching.....	98
Figure 5.2: TVET teachers' understanding of TPACK.....	100
Figure 5.3: TPACK and Technology Integration in VET.....	102
Figure 5.4: TPACK and Technology Integration in TVET	102
Figure 5.5: An extract of the TPACK diagram from the semi-structured interview schedule	111
Figure 5.6: Shilongo explaining technical drawing during a class	116
Figure 5.7: An extract of Shilongo's lesson plan for auto mechatronics	120
Figure 5.8: Ndangi's lesson plan	136
Figure 5.9: Angula with one of his students working on the engine of a vehicle.....	149
Figure 5.10: Lesson plan for air conditioning and refrigeration.....	194
Figure 5.11: Class Attendance for <i>air conditioning and refrigeration</i>	197
Figure 5.12: One of the classrooms used for air conditioning and refrigeration lessons.....	198
Figure 5.13: Laboratory for <i>air conditioning and refrigeration</i>	199
Figure 5.14: A picture of the Global Warming Potential technology used to lower ozone-depleting substances.....	200
Figure 5.15: An extract of a question paper from the internet that Iyambo once used as a sample to design his question paper	203
Figure 6.1: Proposed TPACK Framework for VET teachers (drawn by the researcher)	247

LIST OF TABLES

Table 2.1: A summary of literature used to demonstrate technology integration and TPACK development from 2010–2022	40
Table 4.1: A summary of the research methodology for this study	64
Table 4.2: Research questions.....	79
Table 5.1: Biographic Characteristics of Participants.....	93
Table 5.2: Rationale and Technological means used for teaching.....	99
Table 6.1: Major sources of TVET teachers' TPACK	231
Table 7.1: Research questions and major findings	258

LIST OF ABBREVIATIONS AND ACRONYMS

AR	Augmented Reality
CAD	Computer-Aided Design
CIP	Computer Integration Proficiency
CK	Content Knowledge
CLC	Collaborative Learning Communities
CollabK	Collaborative Knowledge
PCU	Perceived Classroom Use
C-TPACK	Collaborative Technological Pedagogical Content Knowledge
DIY	Do It Yourself
FGD	Focus Group Discussion
ICT	Information Communication and Technology
LMS	Learning Management Systems
LoTI	Level of Technology Integration
MAP	Measure of Academic Progress
MHETI	Ministry of Higher Education, Training, and Innovation
NAMCOL	Namibia College of Open Learning
NTA	Namibia Training Authority
NUST	Namibia University of Science and Technology
PCK	Pedagogical Content Knowledge
PLC	Professional Learning Communities
PK	Pedagogical Knowledge
SAARMSTE	Southern African Association for Research in Mathematics, Science and Technology Education
SDL	Self-Directed Learning
SLR	Systematic Literature Review
SRL	Self-Regulated Learning
TAM	Technology Acceptance Model
TCK	Technological Content Knowledge
TK	Technological Knowledge
TPACK	Technological Pedagogical Content Knowledge

TPCK	Technology Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
TVET	Technical Vocational Education and Training
UNESCO	United Nations Education Scientific
VET	Vocational Education and Training
VR	Virtual Reality
VS	Virtual Simulation
VSBT	Virtual Simulation-Based Training
WVTC	Windhoek Vocational Training Centre

CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.1 Introduction

This chapter provides the background context and rationale for the study to explore Technical Vocational Education and Training (TVET) teachers' technology integration and Technological Pedagogical Content Knowledge (TPACK) development in Vocational Education and Training (VET). Technology integration and TPACK development consist of worldwide concepts, perspectives, national actions, and achievements realised in preparing the ground for technology use in education. In the chapter outline, sections are arranged as follows: the background and context of the study; a statement of the problem; the significance of the study; research objectives; research methodology; definition of terms; structure of the thesis, and the chapter summary.

1.2 Background and Context of the Study

Over the years, VET has experienced a paradigm shift due to the use of digital technology in teaching and learning (Kanwar et al., 2019). The paradigm shift has transformed the landscape of teaching and learning in TVET and created a need for instructors (teachers/lecturers) in vocational training to adopt and integrate digital technologies. Koehler and Mishra (2016) emphasise that meaningful technology integration occurs when specific technologies are intentionally chosen with a clear pedagogical purpose to enhance particular teaching methods. This selection should be closely aligned with curriculum objectives and teaching–learning activities. Harris et al. (2009) contend that effective technology integration in teaching is achievable only when teachers have the specialised knowledge required to teach using technology. This knowledge is referred to as “TPACK” (Koehler et al., 2013), which is a framework that emphasises how instructors integrate technological knowledge with pedagogical approaches and content expertise to improve teaching effectiveness. However, some teachers may not have received formal or informal training in technology integration during their initial teacher education programmes (Abedi, 2024; Jones & Dexter, 2018). As a result, these teachers choose to pursue self-initiated learning to develop TPACK, enabling them to incorporate technology into their teaching practices.

Instructors must therefore adopt advanced technologies to help students solve complex problems and achieve high learning outcomes (Alfalah, 2018). The shifting of education into virtual teaching and learning has, for example, allowed students to access information online (Archambault et al., 2022; Green et al., 2020), while in other contexts, video games and simulation are used to teach complex educational content (Gentile, 2021; Sáez-López et al., 2015). Hence, there is no doubt that digital technology has become significant in 21st-century educational practices (Insel, 2018).

Recent studies have highlighted the importance of developing VET students' 21st-century skills so that they can participate and learn in different fields or disciplines such as auto mechanic, plumbing and pipefitting, joinery and carpentry making, clothing production, building and plastering and electrical (Badenhorst et al., 2020; Cesco et al., 2021; Strayhorn, 2018). On the same note, there are no general definitions of VET, only those included in the legal documents, such as acts of various countries and those in specific countries' contexts (Joynes et al., 2019). For example, in Croatia, VET is defined as a process of acquiring competencies (knowledge and skills) with the results evaluated and confirmed in a procedure carried out by VET institutions (Rohr-Mentele et al., 2021). Some countries, such as Germany, define VET as per its sub-parts: vocational training preparation, initial training, further training, and retraining (Spaans et al., 2018). Within this view, VET training that provides for 21st-century technologies in its programs imparts the vocational skills, knowledge, and qualifications (vocational competence) necessary to engage in skilled occupational activity in a changing working world. Similarly, Gul et al. (2019) confirm that technology in the 21st century continues to shift how industries operate, hence the need for VET curriculum developers and instructors to offer learning experiences incorporating technologies. Therefore, to address the ever-changing learning needs of the students because of the technological environment, Turugare and Rudhumbu (2020) urge vocational training institutions to incorporate the use and integration of technology in teaching.

Teaching in VET has been daunting for years (Mahmut, 2020; Shomirzayev, 2022) because of the nature and structure of the trades and the specific skills students must acquire. Moreover, VET trades and disciplines are more practical, requiring students to develop practical knowledge and skills. For instance, for students to develop practical knowledge and skills, TVET teachers should acquire specific competencies on how students master the principles of completing a job and apply the application to practice (Lowell et al., 2020). Such competencies include the competence of teaching using the appropriate technological media or tools.

González-Pérez et al. (2022) emphasise that the demand to impart 21st-century skills to VET students reinforces the use of technology in education.

Historically, teacher competence was primarily defined by mastery of subject matter (content knowledge) and effective teaching methods (pedagogical knowledge) (Shulman, 1986). However, Shulman (1987) later argued that these elements alone were insufficient to fully capture a teacher's expertise. To address this, he introduced the concept of *PCK*, which emphasises the combination of Content Knowledge (CK) and Pedagogical Knowledge (PK) to effectively present and adapt subject-specific content in ways that promote student understanding (Shulman, 1987).

Koehler et al. (2009) posit that to integrate technology and facilitate teaching and learning activities, instructors need to possess specialised knowledge, called *TPACK* to guide technology integration in teaching (Koehler et al., 2006). Although *TPACK* highlights the knowledge that TVET teachers should possess to integrate technology into teaching, it does not explicitly mention how such knowledge should be acquired. On the other hand, the literature indicates that most instructors in VET were trained in different contexts and environments compared to the ones in which they teach. For many instructors, developing competency with emerging technologies and practices remains a barrier to using technologies in their teaching. Therefore, the study used the *SDL* theory to understand how TVET teachers self-initiate learning to acquire the Technological Pedagogical Content Knowledge (*TPACK*) to integrate and use technologies into teaching and develop *TPACK*. Caffarella et al. (1999) observed that such self-initiated learning experiences, which can be both formal and informal, might help TVET teachers adapt and adjust to develop new knowledge as they progress through different stages in their careers. Moreover, Perera (2022) states that *SDL* allows instructors to learn at their own pace, using their self-acquired materials and testing their progress. This study assumes that self-initiated learning may enable some TVET teachers to integrate technology into their teaching practices while enhancing their *PCK*. This process could provide empirical evidence of the evolution of *TPACK* within VET.

Bereczki et al. (2021) and Jawad et al. (2021) highlight that integrating technology into education could improve the presentation of subject content creatively and enhance understanding and innovative thinking by students. For example, technology in teaching can help students to simulate the work environment in the classroom. Moreover, embedding technology into pedagogy and content makes teaching and learning flexible and convenient for

both instructors and students (Olayinka et al., 2023), making students take charge of their learning.

International organisations such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO) advocate and highlight the significance of digital technology in TVET, noting that the evolving technologies for teaching skills and vocational education are continuously reshaping the roles of teachers and trainers (Beer & Mulder, 2020). While digital technology may introduce innovative learning approaches, it can never replace educators, who should remain central to the integration of ICT into learning environments. Therefore, UNESCO-UNEVOC is actively working to identify emerging trends, innovative methods, and approaches for integrating TVET teaching across various settings, including classrooms, workshops, and workplaces (UNESCO, 2018). Their efforts are centred on defining the critical digital competencies and skills needed to ensure TVET teachers remain prepared for the future.

The African Union acknowledges the significance of TVET and advocates the incorporation of vocational training into the mainstream education system (African Union, 2018). This was demonstrated by the Africa TVET Regulators Conference, which emphasised digital transformation and the governance of TVET systems, aligning with both the TVET Strategy and the African Union's strategy for the digital transformation of education in Africa. The key themes included reviewing a strategy for blended TVET as part of the African Union Digital Education Strategy implementation, advocating diverse approaches, models, and tools to enhance skills development systems in Africa, and fostering collaboration and partnerships among TVET regulatory bodies. In addition, the conference sought to develop a strategy and action plan for digitally transforming TVET in Africa through Open and Distance Learning (African Union, 2018).

Namibia recognises the importance of digital technology and its integration into TVET's teaching and learning to enhance technical and vocational skills, contributing to the country's economic growth and development as a developing nation. Notably, as an attempt to address technology integration into education, the NATIONAL POLICY FOR ICT IN EDUCATION in Namibia was developed in 2005, followed by the National ICT Implementation Plan in 2006 (Simon et al., 2015) to guide the deployment of ICT in VET. This indicates that the integration of technology in education is part of an ongoing, nationwide effort rather than a recent or standalone development. Therefore, the study aligns with these established national initiatives, highlighting its relevance and significance in the current context. Researchers have defined

ICT differently; therefore, there is no universal definition of ICT (Gelter et al., 2021). For example, Yadav (2016, p. 11) defines ICT as “skills around computing and communications devices, software that operates them, applications that run on them, and systems that come with them”. Furthermore, researchers such as Demestichas et al. (2020) and Ghasempour (2019) explain that ICT encompasses many technological tools and resources for communication, creation, distribution, storage, and information management. In this study, I used the terms ‘ICT’ and ‘digital technology’ interchangeably to mean the same thing. Furthermore, the Namibian government introduced many professional development programmes for instructors, such as the Education and Training Sector Improvement Programme, the International Computer Driving Licence, and Tech/NA! ICT Implementation Plan, and the Initiative for Namibian Education Technology (iNET).

To increase and encourage instructors in Namibian VET to become part of the world of ICT, the Namibian government introduced the ICT literacy and technology integration project in teaching and learning training programmes for instructors in 2017. The project signifies the beginning of training in technology for instructors throughout the country to ensure that they are well-equipped and resourced to enhance the use and integration of ICT into teaching the selected content through suitable pedagogical practices. During the training, instructors were provided with internet technologies, digital projectors, laptops, and other technologies to contribute to the teaching and learning environment in the VET classrooms, creating a learner-centric education. In support, Bond et al. (2020) advise that other organisations should support government initiatives to provide technologies in VET programmes to increase the means through which students can access education, and that teaching becomes better because of technology integration (Bernard et al., 2018; Kalonde, 2017; Mertala, 2019).

In recent years, the private sector, international organisations, and some non-governmental organisations in Namibia have also taken it upon themselves to assist and support the government in achieving its educational objectives and goals (Halberstadt et al., 2021). For example, some VET centres in Namibia have access to basic technological infrastructure. Students access learning materials via an eLearning portal made possible by contributions of the European Union through their funded and Deutsche Gesellschaft Für Internationale Zusammenarbeit-implemented project titled the NEV-TVET Hub (<https://elearning.nta.com.na/>).

VET centres such as the Nakayale Vocational Training Centre in Outapi in the northern part of the country have opted to offer a few of its vocational courses online through Moodle, a Learning Management Systems (LMS) to pilot online courses. In 2021, the same VET centre introduced a programme called Blended Distance Learning, in which students learn online through simulations and attend a few face-to-face lessons per semester (Henrich, 2023). To support the initiative, Shambare et al. (2022) and Samuel et al. (2019) posit that the use of chalk and duster is insufficient in the present day and age.

Furthermore, several institutions of higher learning have also developed initiatives to enhance the capacity to incorporate technology into teaching, and learning relies on both technical proficiency and the ability to apply PK. For example, the University of Namibia in 2011 introduced a module called Integrated Media and Technology Education into the Bachelor of Education programme intended to equip aspiring teachers with the necessary knowledge, skills, and attitudes needed to integrate media, information, and communication technologies into teaching and learning environments (Henock, 2015). With such initiatives taking place in VET in Namibia, a need existed for a study focusing on how instructors integrate technology into VET classrooms.

Despite the widespread interest in digital technology and its integration in TVET, how TVET teachers integrate technology and develop TPACK continues to be a focus of scholarly inquiry, remaining a key topic in recent academic literature within the field of educational technology. For instance, Major and McDonald (2021) reviewed 13 peer-reviewed and published articles to identify practices related to improved TPACK among university instructors. Jiménez Sierra et al. (2023) identified 16 papers published between 2015 and 2021 that study TPACK development. It is important to highlight that most of these studies have primarily concentrated on pre-service and in-service teachers in developed countries, with comparatively fewer investigations conducted in developing nations.

Teachers' TPACK is vital for empowering them to use technology for pedagogical purposes in any context effectively. Therefore, understanding how TVET teachers in Namibia develop TPACK is significant. This study aimed to explore the individual TVET teachers' practices, insights, and experiences that influence technology integration and TPACK development from the perspectives of TVET. Further, individual instructors' desire to better use technology for teaching and their TPACK development as self-initiated learning experiences provided the rationale for this study.

1.3 Statement of the Problem

Governments around the world emphasise TVET as a vital education for advancing both individual and national social and economic development (Olabiya, 2023). However, Nascimbeni (2020) noted that most instructors in TVET in developing countries struggle to teach some of the emerging difficult disciplines and concepts such as mechatronics, smart manufacturing, green TVET, and sustainability and eco-friendly construction among others, which if not addressed could have impacts on socioeconomic development. This is in line with other scholars' arguments that TVET teachers are impacted by trends such as digital transformation, including industry 4.0, new teaching paradigms and approaches, including competency-based education, migrations and new demography, climate change, new forms of entrepreneurship and increased networking and collaboration (Evans et al., 2023; Koobonye, 2020; Mancotywa, 2023). In the same vein, most TVET teachers face students who are technologically advanced and also teach in technologically infused classrooms. Therefore, I argue that instructors (TVET teachers) can effectively teach these emerging, complex disciplines and concepts with the aid of technology. When integrating technology into teaching and learning, most instructors face the challenges of their limited knowledge and skills, their attitudes and beliefs, and the lack of support and resources within their institutions (Cardullo et al., 2021; Johnson et al., 2016; Ottenbreit-Leftwich, 2018). Further, instructors' experiences, perceptions, and attitudes correspond to their negotiation of a balance of technology, pedagogy, and content (Kereluik et al., 2011). Moreover, due to the pace of the evolution of technology, some instructors seem to find it cumbersome to adapt to the changes technology brings and decide on what technology to use in teaching and learning.

In particular, teaching with technology in the 21st century, VET institutions require instructors to possess TPACK (Monteiro et al., 2020). However, encouraging instructors to adopt technology in VET institutions remains a challenge. Similarly, in Namibia's vocational education, the presence and access to technologies in VET programmes and self-initiated technology integration learning experiences seem to offer instructors opportunities to develop competencies that expand their practices (Miller, 2020; Nepembe and Simuja, 2023). Fahnoe et al. (2013) state that the presence and access to technologies in VET might instigate some instructors' self-initiated technology learning experiences in schools as it could aid them to adapt and change their practices as they progress throughout their teaching journey (Zainuddin et al., 2019). Therefore, it is assumed in this study that as instructors access various technologies, they develop competencies by reflecting on their own experiences and abilities

and their approach to teaching. The study further assumes that some instructors, through self-initiated learning, choose the appropriate technology to use as part of their pedagogical approach to delivering content material.

This study argues that instructors need knowledge of specific technology, such as its affordances and constraints, adaptive strategies, and learning how to use these aspects of technology to enhance comprehensive teaching and learning. Moreover, as a part-time lecturer in VET for the past 10 years, I can attest that with emerging technologies appearing in the classroom, effective technology integration has moved to the forefront as these technologies support the teaching and learning of content. As instructors, we interact with various digital technologies throughout our daily routine; however, I observed that most instructors do not fully understand how to use these technologies to improve teaching practices. Following the findings of Mishra et al. (2006), through self-initiated learning of technologies, some instructors seem to build on good pedagogical practices (pedagogical knowledge), technological skills (technological knowledge), and content presentations (content knowledge) and understand the inter-relationship of these knowledge (TPACK). Owing to the direct link between the self-initiated learning experiences and the instructors' roles (Khan et al., 2020; Shaalan, 2019; Tam, 2000), researchers should perceive instructors' TPACK development experiences through an adult learning lens. Individually guided TPACK development assumes that instructors, as adult learners, are self-initiating learners and integrate technologies most effectively when they initiate and plan for learning activities that are relevant to their own goals (Hawkins, 2018; Olayinka et al., 2021; Shambare et al., 2022).

In line with other TPACK researchers (see Philogene et al., 2024; Sako, 2020; Terblanche, 2017), I noted that, despite the lack of formal guidelines, TVET teachers in Namibia independently integrate technology into their classrooms to address their students' needs. In addition, the study indicates that these teachers might unknowingly be developing TPACK in the process. This reveals the possibility of more complex and deep sources contributing to TPACK development beyond formal technology-based training. Consequently, this exploratory multi-case study explored how TVET teachers in Namibia, whether trained through ICT workshops or formal learning do self-initiated learning efforts to integrate technology and develop TPACK. There is a notable lack of empirical research on how TVET teachers in Namibia achieve technology integration and TPACK development, particularly compared to studies in developed countries. Previous studies on TPACK development in general in Namibia were conducted by Simon (2019, 2015) and Henock (2015). All these studies focused on technology integration and TPACK development in other teaching contexts such as pre-service and in-service teacher education, primary and secondary education, and universities.

Furthermore, the few available studies on TPACK in TVET in Namibia were conducted by Eiseb (2024), Nepembe and Simuja (2023), Kapolo (2024), Mutelo (2023), and Uandara (2023), and mainly focused on TVET teachers' perspectives on TPACK, TVET instructors' perceptions of digital technology use and support, implications of pedagogical integration of ICT in TVET and effectiveness of eLearning in TVET respectively. Importantly, there has not been any research in Namibia that has shed light on the way individual TVET teachers integrate technology and develop TPACK. Thus, there is a knowledge gap regarding TVET teachers' TPACK. Therefore, this study aimed to contribute new knowledge on how individual TVET teachers integrate technology into teaching and learning and develop TPACK as a foundation of their self-initiated learning practices, insights, and experiences in Namibia.

1.4 Significance of the Study

Like many other countries, the Namibian government, in collaboration with various NGOs, has made considerable efforts to ensure that technology is integrated into teaching across all educational institutions. However, researchers have identified a lack of comprehensive theoretical and professional frameworks to support, guide, and enhance teachers' effectiveness in integrating technology into classroom instruction (Hennessy et al., 2022; Guggemos et al., 2021; Mohebi, 2021). Multiple approaches have been explored to support teachers in

addressing the challenges of incorporating technology into TVET (Okolie et al., 2023). An effective approach to providing technological support involves using a framework that seamlessly integrates pedagogy, content, technology, and dynamic interactions within the classroom (Alam et al., 2023).

Falloon (2020) identifies teachers as critical players in assisting students in acquiring the relevant knowledge and skills necessary for the industry. As a TVET teacher, I can confirm that our lesson plans intentionally incorporate audio-visual technologies, from basic technologies like PowerPoint presentations and YouTube videos to more advanced technologies such as animations and simulations. This aligns with Koehler et al. (2008), who argue that teachers can naturally develop TPACK at different stages, from lesson planning to assessment, often without formal training. Therefore, this research is essential as it explores how TVET teachers in Namibia can acquire TPACK despite lacking formal instruction in technology integration. Therefore, the findings of this study might offer valuable insights into how instructors develop their TPACK and integrate technology into their teaching to enhance skills acquisition.

The researcher's experience as a TVET teacher in Namibia inspired this study was driven by a professional responsibility to teach trainees using technology. The primary goal is to explore how TVET teachers integrate technology and develop TPACK within their institutions. Gaining insight into the strategies, best practices, and contexts in which TVET teachers acquire TPACK can help identify the necessary support for building or enhancing it. Additionally, TVET teacher participants had opportunities to share their experiences with self-initiated learning and technology integration, deepening their understanding of TPACK. This awareness may encourage them to refine their teaching practices and adapt to an increasingly technology-driven educational environment. As a VET instructor, the activities and findings from this study might provide me with information to understand how other instructors develop TPACK-integrated technology to affect teaching. Theoretically, this study brought together two previously separate research traditions, namely, the Self Direct Learning theory(SDL) and the TPACK framework, which shows how the two theories enrich and empower each other in the concrete and complex challenge of the evolution of TPACK. This research does not seek to introduce a new area of inquiry into TVET teachers' TPACK development, as previous studies have explored this topic (e.g., Kapolo, 2023; Beukes, 2024; Simon, 2015). However, what distinguishes this study is its focus on the context-specific and situated nature of TPACK development among TVET teachers. By centering on TVET education, this research addresses

a critical yet underexplored area within academic inquiry. The limited attention given to TVET settings highlights the significance of this study, as it seeks to fill a gap in understanding how TVET teachers develop TPACK within their unique teaching environments. While prior studies (Ausiku, 2022; Simuja & Silvanus, 2023) have examined TPACK in pre-service teacher education, limited research has explored its application in TVET contexts. This study contributes new insights into how in-service TVET instructors in Namibia develop TPACK, addressing a critical gap in vocational education research.

1.5 Research Objectives

The research's main objective was to examine the multi-case of TVET teachers' TPACK development in Namibia's VET centres. Specifically, the study aimed to achieve the following objectives:

- To explore the TVET teachers' self-reporting descriptions of their TPACK in VET.
- To determine the sources of TPACK the TVET teachers draw upon during self-initiated learning of integrating technology in the classroom.
- To find self-initiated learning activities that support and constrain TVET teachers in integrating technology into teaching.
- To explore the support TVET teachers need to integrate technology into teaching and develop TPACK.

1.6 Research Questions

- How do TVET teachers self-report and describe their TPACK in VET?
- What TPACK sources do TVET teachers draw upon during self-initiated learning of integrating technology in the classroom?
- How do self-initiated learning activities support and constrain TVET teachers to integrate technology into teaching?
- What support do TVET teachers need to integrate technology into teaching and develop TPACK?

1.7 Research Methodology

The study adopted a qualitative multi-case approach to explore how TVET teachers integrate technology and develop TPACK in VET. The study was embedded in the interpretive paradigm

to draw in-depth insights, personal experiences, and opinions of the different cases or participants. The study used questionnaires, semi-structured interviews, non-participatory classroom observations, and focus group discussions to collect data. The six cases from a population of 20 VET teachers who answered the questionnaire across Namibia indicated their willingness to participate in semi-structured interviews, non-participatory classroom observations, and focus group discussions. Through thematic analysis, the study inductively analysed the data with the support of the NVivo software version 22.

1.8 Definition of Terms

Below are the definitions of the terms used in the study.

Technology in the context of education involves applying scientific knowledge, skills, and tools to enhance learning, innovate teaching methods, and solve practical problems within educational settings, including the use of digital tools, LMSs, instructional processes, and innovative techniques to achieve specific educational goals or objectives (Hevner & Gregor, 2022).

Technology integration refers to the purposeful use of various technological tools and resources to support and enhance education (vocational education) teaching and learning processes (Emre, 2019).

Vocational Education Training (VET) refers to an education that provides individuals with practical skills and knowledge directly related to specific industries, trades, or occupations (Pambudi & Harjanto, 2020).

Technological Knowledge (TK) is the understanding of how to use and apply various technologies (Tanak, 2020). TK goes beyond basic technical skills and includes knowledge of tools, software, and hardware relevant to teaching and learning.

Pedagogical Knowledge (PK) refers to principles and methods of teaching, including an understanding of instructional strategies, classroom management, assessment techniques, and the psychology of learning (Celik, 2023).

Content Knowledge (CK) is expertise in the subject matter being taught (Kaya et al., 2021). It involves profound understanding of a discipline's concepts, theories, and principles.

Technological, Pedagogical, and Content Knowledge (TPACK) is a framework that integrates the TPACK, which is essential for effective teaching with technology (Malik et al., 2019).

1.9 Structure of the Thesis

The study comprises seven chapters contributing to the detailed exploration of the research questions and the overall understanding of TPACK development in the context of VET. This thesis is structured into seven chapters as follows.

Chapter One: Introduction and Background provides a very detailed background and rationale for the study including concepts, theories, and perspectives of the context in which the study is embedded. The chapter highlights the general worldwide view and the Namibian context regarding technology integration in TVET. It also presents the problem statement, the significance of the study, an overview of the research methodology, research objectives, each question, and the definition of terms.

Chapter Two: Conceptual Framework presents the relevant literature and works of previous researchers on technology integration and TPACK development in education. The study uses a systematic literature review from several databases such as Google Scholar, EBSCOhost, Web of Science, and Science Direct. The study drew most of the literature reviews presented in this chapter from the international sphere, including North Africa, due to shortages of studies in sub-Saharan Africa.

Chapter Three: Theoretical Framework highlights the theoretical frameworks that guided the study. The study presents a combination of the TPACK and SDL frameworks and an in-depth description of the individual frameworks, which also serve as analytical frameworks. The chapter also discusses the suitability of these frameworks for the study.

Chapter Four: Methodology outlines the study's procedures for collecting data. The chapter discusses and justifies the selection of the research design, interpretive paradigm, multi-case approach, purposive sampling, and data collection instruments. The chapter also highlights the data analysis strategies, the validity and trustworthiness of the data, and the research ethics.

Chapter Five: Presentation and Analysis of Results presents the study's findings in relation to the research objectives and questions. First, the chapter presents and analyses the quantitative findings from the questionnaire. Secondly, the chapter presents the qualitative data collected through semi-structured interviews, non-participatory classroom observation, and focus group discussion for each of the six cases.

Chapter Six: Discussion of Findings presents the discussion of the findings to the research objectives and justifies them with literature and theoretical frameworks. This chapter emphasises the consistency and alignment of the findings with the research objectives, methods, literature, and theoretical frameworks.

Chapter Seven: Summary of the Findings, Conclusion and Recommendations provides an overview of the entire study and a summary of the findings per the research questions and the implications for practice and future research.

1.10 Chapter Summary

The chapter provided a rationale for exploring the evolution of TVET teachers' TPACK development in vocational training centres through a multi-case study approach. The chapter begins by presenting the background, highlighting the significance of understanding how technology integration and TPACK evolve within the unique context of VET. It underscores the increasing importance of technological skills in the workforce and the role of TVET teachers in preparing students for real-world vocational challenges. Moreover, the study established the rationale for the study, emphasising the existing gap in research that predominantly focuses on TPACK in contexts other than TVET. The introduction makes a compelling case for investigating TPACK specifically within the domain of VET, setting this study apart from previous research endeavours. As a developing country, Namibia has made strides in rolling out its ICT policy and providing training to equip TVET teachers with technological knowledge, which, together with pedagogical and CK, enables TVET teachers to integrate technology into teaching and eventually develop TPACK. Namibia has implemented several programmes to enhance TVET teachers' understanding of technology and its impact on teaching and students' learning.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

In the previous chapter, I provided an introduction and background to the study, including the problem statement, research objectives, research questions, the significance of the study, limitations, and delimitations. This chapter focuses on the review of related literature. A review of related literature is a critical analysis of existing academic research and scholarly articles related to a specific research topic or question (Linnenluecke et al., 2020). According to Snyder (2019), a review of related literature involves conducting a comprehensive search of relevant literature, analysing, and synthesising the findings, and providing an overview of the existing knowledge on the topic.

Previous research reveals that scholars review relevant literature for several purposes. Firstly, it helps to identify the research gap, which is the area that has not been studied or addressed in previous research. Secondly, it provides a theoretical framework that helps to guide the research design and methodology. Thirdly, it helps to identify the key concepts, variables, and relationships that are relevant to the research topic and provides evidence to support the research hypotheses and justifies the research objectives (Hennink et al., 2020; Pappas et al., 2021; Pradhan et al., 2018).

There are several types of literature review, each with its purpose and methodology (Snyder, 2019), and the common types of literature reviews are narrative literature review, systematic literature review, meta-analysis, scoping review, rapid review, and critical review (Grant et al., 2009). According to Xiao and Watson (2019), the narrative literature review is a comprehensive summary of the existing literature on a particular topic, typically including quantitative and qualitative studies. Leonardi et al. (2019) posit that a narrative review does not involve statistical analysis but rather focuses on the synthesis of ideas, concepts, and themes. However, it provides a comprehensive overview of the research in a particular field or topic, highlights important concepts and themes, and can identify gaps in the literature that need further exploration (Rowland et al., 2019). A systematic literature review is a rigorous and structured approach to reviewing the literature on a specific topic (Paul et al., 2021). Peters et al. (2020) explain that the structured approach involves the identification of research

questions, the development of search criteria, the screening and selection of studies, the extraction and analysis of data, and the synthesis of findings. In addition, meta-analysis is a statistical technique used to combine the results of multiple studies, especially quantitative studies, to calculate the overall effect size (Veroniki et al., 2019), while a scoping review is a type of literature review that aims to map the key concepts, evidence sources, and research gaps in a particular field (Munn et al., 2018). Scoping reviews are broader than systematic reviews and may include a more comprehensive range of study designs and sources. Researchers can also use a rapid review as a streamlined version of a systematic review in a shorter time frame. Rapid reviews typically involve simplifying the search strategy, limiting the inclusion criteria, and reducing the scope of the review (Cartaxo et al., 2020). Lastly, the critical review evaluates the quality and relevance of the literature on a particular topic. Critical reviews focus on the research methods' strengths and weaknesses, the results' validity, and the implications for practice (Huber et al., 2020).

Given this range the current study adopted the SLR approach because it clearly outlines the actions and procedures for finding, choosing, verifying studies, and presenting their findings (Papaioannou et al., 2016). An SLR provides a structured, transparent, and unbiased approach to identifying, evaluating, and synthesizing literature for comprehensive reviews in the VET sector. The study adopted the SLR as it involves more rigorous methods of literature reviews. Mohamed Shaffril et al. (2021) argue that SLR offers complete coverage of all the evidence published on integrating technology. Further, I used SLR to provide a conceptual framework to foreground the research problem's development and activities.

The customary method of reviewing literature concentrates on publications by academic presses and articles published in scholarly journals, which would remain the suitable focus for numerous intents (Kushwah et al., 2019; Neves et al., 2020;). Although there is a wide range of sources to derive existing knowledge on a topic or phenomenon, some sources, such as the internet, must be used with caution since a lot of posts lack sufficient research, exhibit bias, and include assertions that are uncertain in terms of accuracy (Landolsi et al., 2023; Tempini et al., 2021). However, I should search for recent and up-to-date work, such as conference papers, working papers, and online monographs, which have either not been published or are works in progress. Some of the most apparent literature primary sources include journals, online sources like e-books, online journals, while periodicals, newspapers, literary blogs, libraries, oral traditions, personal experiences, and books that can be fiction or nonfiction act as supplementary and can cover a wide range of topics. The study conducted an SLR by

accessing online journal articles from databases like Google Scholar, EBSCOhost, Science Direct, and Springer. Articles were selected based on inclusion and exclusion criteria, focusing on publications from 2010 to 2022. The search used concepts such as technology integration, VET, online teaching, the TPACK framework, challenges of technology integration in VET, and the development of TPACK in teaching and learning.

I outline the chapter as follows: first, I present an overview of teaching and learning in VET; second, the TPACK in VET; third, I present the review of literature on the integration of technology in teaching and learning in VET; fourth, the integration of technology into teaching and learning in other contexts; fifth, barriers to technology integration into teaching and learning in VET and, lastly, the development of TPACK in teaching and learning in VET.

2.2 The term “Instructor”

This section provides an overview of the term “instructor” in relation to other terms such as educator or teacher for VET trainer as understood in the context of this study.

The term "instructor" is considered misleading due to varying interpretations and definitions among scholars. In the context of TVET teacher development, there is no universally accepted definition of a "TVET teacher" and the terms "TVET teacher", "TVET trainer" and "instructor" are often used inconsistently. Some institutions differentiate between these roles, while others use them interchangeably. For example, in Georgia, an instructor refers to a vocational teacher responsible for both theoretical and practical content in TVET programmes (Ahmid et al., 2023; Hashim et al., 2019; Njenga, 2022), whereas in other African countries, "TVET teacher" generally applies to educators in secondary schools and public TVET colleges. "Trainer" often describes professionals involved in apprenticeship systems and private-sector training, with CEDEFOP defining a trainer as a skilled worker who mentors apprentices and trains co-workers.

Nevertheless, the current study embraces the general definition by Hamdan (2020) that a “TVET teacher” typically denotes a more theory-oriented educational role, whereas “trainers” and “instructors” often emphasise practical skill development and work quality. Therefore, to reflect the technology integration and TPACK development in VET, for which the curriculum or content is theoretical and practical, TVET teacher, trainer, and instructor have been used interchangeably to include shared meanings, contextual overlap, or a need for clarity and that the study can be understood in different contexts. Regardless of the terminology used, TVET

teaching staff must have a solid foundation in pedagogy and didactics and a deep understanding of the workplace, job tasks, and processes.

2.3 An Overview of Vocational Education and Training (VET)

According to Autor (2014), the progress and advancement of a country's economy and society depend on the abilities and expertise of its people. There has been an increasing stance on the importance of VET education over the years due to changes in sectors of the economy. However, different contexts employ terms such as TVET, VET, and technical vocational education to describe vocational training education. As a result, this study uses these terms interchangeably to accommodate all contexts (Kumar & Singh, 2018). Meanwhile, Pongo et al. (2015) emphasise that TVET plays a crucial role in equipping individuals with the necessary skills and entrepreneurial mindset to meet the demands of an evolving technological workforce. TVET plays an essential role in national development plans due to its significant impact on productivity, economic growth, and overall progress (Bala et al., 2019; Nalathambi et al., 2023). Hence, the learning processes within TVET are tailored to align with the needs of the manufacturing industry, prioritising practical skills and addressing work-related concerns (Abdullah et al., 2022; Melesse et al., 2022). Antera (2022) highlights that the vocational teacher's role is to shape and deliver content that aligns with workplace conditions. Therefore, the curriculum content should be tailored to meet the context and goals of the workplace. Thus, according to Nepembe and Simuja (2023), the TPACK framework is broad and may not fully suit TVET unless it is tailored to fit its specific context.

TVET aims to enhance an individual's abilities, skills, and knowledge to secure employment and lead a comfortable life (Alagaraja et al., 2014). According to Hashim et al. (2022), TVET is a skills educational programme that offers distinct instructional methods separate from other formal educational systems. It focuses on providing specialised technical skills to individuals. For example, Debrah-Karikari et al. (2018) and Moodie et al. (2019) define TVET as any training, curriculum, or programme that equips students or individuals with the necessary skills and knowledge to engage in practical work as either semi-skilled workers or expert professionals within a specific occupation. Further, Harun et al. (2020) posit that TVET focuses on attaining knowledge and skills applicable to employment. Comfort (2012) states that TVET should focus on obtaining knowledge and skills relevant to the working environment, aiming to enhance opportunities for productive empowerment and socioeconomic development within

knowledge-based economies and rapidly evolving work settings. However, a UNESCO definition has been adopted in this study as

a comprehensive term referring to those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding, and knowledge relating to occupants in various sectors of economic and social life (Badawi, 2013, p. 284).

According to Guo et al. (2020), in developing countries, secondary schools often have technical and vocational education programmes that prepare students with technical work skills. Therefore, the ultimate objective of all TVET initiatives is to equip individuals with the necessary skills and expertise required for productive work within a specific occupation or employment. However, TVET systems are designed to educate and train the skilled workforce needed by a country to generate economic prosperity and overcome poverty (Baumgartner et al., 2016). Consequently, one notable characteristic of TVET is its flexible delivery at different difficulty levels. The flexibility means that TVET programmes can cater to various industries' specific demands and a wide range of individual needs and aspirations (Salleh et al., 2020).

Chakroun (2019) states that TVET encompasses diverse activities involving training, preparation, and skills development in various occupational fields, including manufacturing, services, and engineering. Furthermore, Ismail et al. (2018) concur that the TVET curriculum has tailored a wide range of skill development opportunities in TVET to meet the needs and requirements of both national and local contexts. Therefore, as part of lifelong learning, vocational education can be offered at different levels, including work-based learning, ongoing training, and professional development that can lead to qualifications (Kanwar et al., 2019).

Several scholars on TVET have explored the theoretical perspectives of TVET. For instance, Mbatha (2024) indicates that despite TVET programs equipping individuals with the essential skills and knowledge required for success in the job market, these programs blend theoretical and practical training, ensuring that individuals develop both technical expertise and hands-on experience. Hauuanga (2023) notes that TVET has two distinct components; technical education and vocational training which complement each other. Technical education provides the theoretical foundation, helping individuals understand the underlying principles of a specific field, whereas vocational training offers practical experience, allowing them to apply that knowledge in real-world scenarios. Furthermore, together, these components create a well-rounded learning experience that prepares individuals for thriving careers. Therefore, by

integrating both components, TVET delivers a comprehensive and dynamic education that is crucial for navigating today's rapidly evolving job market.

Moreover, Okolie et al. (2023) state that the theoretical part is accompanied by different pedagogical practices that teachers can adopt to facilitate quality TVET learning which include demonstration of learning, problem-based learning, seeing individuals as knowers, active learning, and questioning.

TVET plays a vital role in driving economic growth and development, African nations should consider adopting and strengthening TVET programs to equip their technical workforce for industrialisation and economic advancement (Ajeniwani et al., 2024; Kerre, 2017). Recognising the increasing demand for skilled professionals, regions such as the European Union, the African Union, and the Middle East have restructured and reformed their training curricula to ensure a steady supply of highly skilled experts (Gyimah, 2020).

2.4 Integration of Technology into Teaching and Learning in VET

Much research has focused on incorporating digital technology into educational programmes (Bulman et al., 2016; Fathema et al., 2015; Granić et al., 2019; Lee et al., 2021). This thesis covers various topics, including classroom technology usage and teacher training courses that align digital technology with course materials. Although many versions of understanding and interpreting digital technologies exist, researchers stated that it was challenging to define digital technology because of the different perspectives and contexts (Toufaily et al., 2021). For example, Moscoso-Zea et al. (2019, p. 251) define Digital technology consists of two main components: physical components like equipment, tools, products, and processes and informational components such as expertise in management, marketing, production, and skilled labor.

Dahlman and Westphal (2019) argue that digital technology is not just about the technology embodied in the product but the knowledge of information for its use, application, and process to develop the product. For instance, emerging digital technologies, including software, hardware, and mobile applications, are transforming teaching and learning. In addition, the term "technology integration" has been coined to describe the efforts to use technology in an educational setting (Kale et al., 2020; Tondeur et al., 2017). Previous research indicates no standard definition of technology integration; however, many scholars have devised various versions of what it could mean (Domínguez et al., 2013; Rauschnabel et al., 2019; Tamim et

al., 2011). For example, some academics perceive technology integration as the categorisation of teachers' use of computers in the classroom (Bayaga et al., 2021; Bowman et al., 2022; Blau et al., 2016), while others view it as the way teachers employ technology to enhance the effectiveness and productivity of familiar tasks and the potential impact of such use on reshaping these tasks (Fütterer et al., 2023; Khatoony et al., 2020; Qi, 2019). Pun (2013) states that technology integration is the use of technology by teachers to teach effectively and stimulate students' thinking. Hermanto et al. (2021) define technology integration as using digital technologies such as computers, smartphones, laptops, software, and the internet by TVET teachers for teaching purposes. Moreover, Deng et al. (2022) expand their definition by noting that technology integration involves integrating technology and technology-related practices, such as collaborative work and communication and internet-based research into the daily routines, tasks, and overall management of schools. This study adopts Hermanto et al.'s (2021) definition of technology integration as it specifies the technological tools or digital technologies considered as technology to be used in achieving intended learning outcomes, complemented by Deng et al.'s (2022) to encompass technology-related practices and internet-based research.

Researchers have extensively studied the use of digital technology in various educational settings and have concluded that the efficacy of technology is not solely dependent on the quality of hardware or software (Fathema et al., 2015; Jensen et al., 2018; Mohamed Hashim et al., 2022). Therefore, the integration of technology into teaching and learning has always been a recurring concern (Szymkowiak et al., 2021), and it is essential to recognise that technology should be viewed as an integral component of instruction rather than as a standalone entity (Falloon, 2020). The success or failure of ICT integration into instruction relies heavily on instructors' perspectives, attitudes, and beliefs, which play a vital role in this process (Alsuhaibani, 2019). Thus, instructors serve as change agents and hold a crucial position in the effectiveness of teaching and learning in VET programmes (Urbani, 2020).

A study by O'Brien (2015) that examined teachers' knowledge and beliefs about teaching with technology in a regional VET institute in Australia found that teachers' beliefs significantly impacted their use of technology. Research has indicated that instructors' epistemological beliefs are reflected in their perceptions of students and thus shape their decisions about integrating technology into their teaching. In another study, Polikarpus et al. (2023) assessed the role of trainers in the implementation process of virtual simulation-based training (VSBT), their attitudes towards the use of Virtual Simulation (VS), and their TPACK in the Estonia

Academy of Security Sciences. The study used a survey among 146 trainers. The study findings revealed that trainers who used VS in their teaching had a more positive attitude towards it than those who did not use it in their work. Moreover, trainers who were trained in using VS had a more positive attitude than trainers using VS to facilitate VSBT. In addition, the study found that combining technological knowledge with pedagogical and content expertise can help trainers implement VSBT in a specific way in their training institutions. The study recommended that future research should also find out what fields in VET benefit more from VSBT and how to support the creation of VS for different domains. Therefore, the effective use of technology in teaching depends on individuals' attitudes and beliefs towards technology.

The above studies highlight that effective technology integration into teaching is strongly influenced by educators' attitudes, beliefs, and knowledge. However, Polikarpus et al.'s (2023) study emphasises that professional development and training are crucial for fostering positive attitudes and equipping educators with the skills needed for technology use. Hence, a recurring theme is the importance of aligning technological knowledge with pedagogical and content expertise (TPACK), emphasising the need for a robust framework to support educators in integrating technology effectively.

Uandara (2023) investigated TVET instructors' perceptions of digital technology use and support at a Vocational Training Centre in Namibia. The study used thematic data analysis with purposive sampling, selecting 11 respondents, including eight teaching staff and three management members. Data were gathered through semi-structured interviews and focus group discussions and analysed using the Provalis Research QDA miner application and Microsoft Word. The Technology Acceptance Model (TAM) served as the conceptual framework, identifying themes such as perceived ease of use, perceived usefulness, and behavioural intention. The findings highlighted that integrating technology into teaching was beneficial, relevant to training objectives, and convenient, contributing to the centre's educational goals. However, challenges included financial constraints, limited IT infrastructure, accessibility issues, and gaps in technical skills. To address these barriers, the study recommended securing funding, planning sustainable infrastructure, and providing comprehensive training for stakeholders. The study underscores a paradox in TVET: while instructors acknowledge the benefits of technology for teaching and learning, progress is hindered by systemic challenges, including financial constraints and inadequate infrastructure. The findings, aligned with the TAM, indicate that overcoming these obstacles could greatly improve instructors' willingness and ability to integrate digital tools into their teaching

practices. Furthermore, the study emphasises the critical role of institutional support in fostering an environment conducive to effective technology adoption. Similar results were found by Nepembe and Simuja (2023) in their study that explored instructors' perceptions of TPACK in a vocational training classroom in Namibia. However, the study further found that the instructors' disposition towards TPACK shifted with access to teaching technologies and that students' learning needs informed the instructors' TPACK. Furthermore, Uandara's (2023) use of TAM as a conceptual framework aligns with the findings of Antonietti et al. (2022), who demonstrate that TAM effectively explains teachers' intentions to use digital tools in vocational education. In addition, there are positive and significant relationships between teachers' beliefs in their digital competence, perceptions of technology's ease of use, and the perceived usefulness of technology for teaching.

Furthermore, research has highlighted different ways in which teachers can integrate technology into teaching: teaching with mobile phones and handheld technologies, using game-based teaching and assessment, giving students project-based activities incorporating technology, offering online education, blended classrooms in which traditional face-to-face teaching methods are combined with online learning activities to create a hybrid approach to education, and using technology-driven tools such as interactive whiteboards, among others (Alam et al., 2021; Lawless et al., 2007; Tondeur et al., 2012;). For instance, Summak et al. (2011) explored VET teachers' instructional and personal technology use and the instructional approach they use in the classroom. The researcher administered 500 questionnaires to randomly selected teachers in 15 K-12 VET schools in Gaziantep Province in Turkey through a quantitative descriptive method. The study adopted the Level of Technology Integration (LoTI) framework to explain better how teachers used technology. The findings of the study demonstrated that the participating teachers exhibited higher levels of LoTI, PCU (Perceived Classroom Use), and CIP (Computer Integration Proficiency). Shulman (1987) emphasises that technological knowledge, one of the domains within the TPACK framework, is the knowledge teachers need to effectively use technologies.

In addition, the study revealed a noteworthy difference between genders in LoTI and PCU scores, with male teachers scoring higher than their female counterparts. However, Kanbul et al.'s (2022) study refuted the result, finding a negative relationship between digital competence and gender. Moreover, the study observed a significant difference between age groups and teachers' PCU scores, with younger teachers achieving higher scores than their older colleagues. This difference in PCU between age groups could be because the young teachers

are more infused with technology and are likely training in technology-rich environments than their older colleagues. Based on the research findings, the study provided suggestions and recommendations. The findings demonstrate that the teachers possess both the skills and confidence necessary to incorporate technology into their teaching practices effectively. Their elevated LoTI, PCU, and CIP levels demonstrate a readiness and ability to use digital tools to enhance educational outcomes. These results may also reflect the effectiveness of previous professional development initiatives or training programmes designed to promote technology integration in education. Since there is limited literature on LoTI in TVET, the research explored literature on general education, for example, Abalkheel et al. (2023) found that a positive correlation exists between instructors' capacity to integrate their CK, effective pedagogical strategies, and technological expertise to enhance students' writing proficiency. However, contrasting findings emerge regarding the level of technology integration. While Abalkheel et al. (2023) and Summak et al. (2011) noted positive results on the LoTI and its impacts on student performance, a study by Hannah (2022) reveals that teachers' level of technology use showed no statistically significant impact on minority students' performance in the measure of academic progress (MAP) examination. These findings collectively portray a varied backdrop of technology integration into education in general and TVET, as observed through the perspectives of these researchers' studies. However, further research is needed to explore whether these high LoTI leads to improved student engagement and learning outcomes or if additional measures are required to maintain and enhance these practices.

A survey by Ramadan et al. (2018) examined the Sudanese teachers' skills and ICT integration into TVET in Khartoum state. The study involved a random sample of 200 respondents, of which 168 (84%) completed and returned the distributed questionnaires. Using a sample of 130 males and 38 females from three different types of TVET institutions, namely, technical secondary schools, artisan institutions, and vocational training centres, data collected was analysed using SPSS version 20, the one-way ANOVA, and the Independent Sample t-test methods. The findings of the study indicate that respondents in this study were similar regarding demographic information and ICT usage skills. However, Ramadan (2018) observed a notable distinction in the ICT skills of the respondents based on their age and qualifications. It is then assumed in this study that age and qualifications play a critical role in determining whether to integrate technology into teaching or not. As a result, additional training is necessary for TVET teachers to enhance their basic computer skills. Ramadan et al. (2018) recommend that pre-service and in-service teachers receive comprehensive ICT skills training.

In pursuit of providing more evidence relating to the age of teachers and technology integration, researchers such as Sánchez-Prieto et al. (2020) challenged the critical role that age and qualifications play in influencing technology integration, as revealed by Ramadan et al. (2018). Sánchez-Prieto et al. (2020) conducted a study to determine whether the age of teachers influences their knowledge about ICT. The study involved 1,568 teachers in the autonomous community of Andalusia to investigate digital teaching competence in Dual VET schools. The study used quantitative and descriptive methods to collect data through a questionnaire. The findings indicated that the overall level of digital competence among the participating teachers was relatively low or moderate across all aspects. In addition, the study revealed that age was only a significant factor in the problem-solving dimension of digital competence. Therefore, although most studies (Hu et al., 2021; Nnaji et al., 2023; Raygan & Moradkhani, 2022) have found that age influences technology integration, this impact is not universal. Age affects technology use primarily in areas where older individuals might face challenges, such as problem-solving, rather than in all aspects of technology integration. Different results on digital competence were found by Kanbul et al. (2022) who examined the literature concerning the competence required by TVET teachers for computer-related instructional technology for classroom teaching and learning through the TPACK model. In this study, Kanbul et al. (2022) distributed 60 questionnaires to technical and vocational education teachers in six colleges of education in northeastern Nigeria. The collected data was subjected to quantitative analysis using both traditional linear models, specifically multilinear regression, and artificial intelligence models, namely artificial neural networks and adaptive neuro-fuzzy inference systems. The findings from the study indicated that TVET teachers exhibited competence in computer usage and certain instructional technologies. In addition, the study observed a strong correlation between competence and teaching experience and a weaker correlation between competence and gender.

Regarding digital competency, the varied findings demonstrate that teachers may possess or lack the essential skills required to effectively integrate digital technologies into their teaching practices. This highlights the need for targeted professional development programmes aimed at improving digital competence, particularly in areas such as content creation, problem-solving, and technology integration. Further research is necessary to investigate other potential influencing factors, such as teacher confidence, institutional support, and external barriers like internet connectivity, which were not fully explored in the study.

Richard et al. (2023) investigate the interplay of knowledge domains necessary for art teachers to integrate technology into teaching within the TVET sector effectively. Employing a quantitative research approach, the study used Structural Equation Modelling to analyse the direct and indirect effects between exogenous and endogenous variables. Data were collected from 152 art teachers across various public educational institutions in Ghana using an online survey instrument grounded in the TPACK model. Analysis was conducted using SPSS and SmartPLS. The findings revealed a strong relationship between art teachers' knowledge and the extent of technology integration into TVET. Key mechanisms identified include mastery of technologies, the use of technology-driven instructional strategies, and teachers' technical knowledge and skills, which are essential for fostering effective skills development in TVET. The study underscores the importance of focusing on these mechanisms to enhance teaching and learning within the TVET ecosystem, particularly for educators, training institutions, policymakers, and stakeholders.

Research has indicated that instructors integrate technology when the technology, content, and instructional strategies match (Taimalu & Luik, 2019). Thus, instructors should embed technology within the content and pedagogy. Instructors should also prepare to use technologies to construct, represent, and share knowledge in authentic real-life contexts, not only about technology. Consequently, instructors can only integrate technology once they possess all three knowledge domains: TPACK. Thus, TPACK is "a unique body of knowledge constructed from the interactions of individuals contributing knowledge bases" (Angeli et al., 2016, p. 72). Further, TPACK enhances instructors' teaching (Malik et al., 2019). Accordingly, effective and meaningful technology integration arises from the interactions and interplay among the three knowledge domains (Tajpour et al., 2022). It is the understanding of the complex relationship between technology, pedagogy, and content that leads to quality and effective teaching.

Arguably, Szymkowiak et al. (2021) posit that previous research conducted on the instructional use of technology has indicated that some instructors, especially in developing countries such as Namibia, often lack the technological knowledge to integrate technology into their teaching, which makes them use minimal technology and remain on traditional teaching. Research has also noted that some instructors should be able to integrate technology resulting from training, attending workshops and conferences, seminars, and self-studying (Koskinen et al., 2018). Rathore et al. (2015) highlight that instructors are likely to use technology if it supports existing pedagogies enabling problem-solving; it is not an isolated strategy aimed at enhancing student-

centered learning, and those instructors attend regular training and ongoing support through developmental programmes. However, the literature indicates that technology skills training provided to instructors is flawed because it is out of context and usually centralised and standardised (Ramadani et al., 2023). Normally provided by governments or education ministries, such training programmes may offer generic technology training that does not align with the specific teaching environment or curriculum needs of TVET institutions (Muchira et al., 2023).

Scoular and Care (2018) highlight that the question is how instructors should impart skills in the 21st century. They further emphasised questions such as what skill sets educators need to have to teach, what pedagogical practices to use, and what instructional materials instructors can use to implement successfully. The literature further narrates that although technology is readily available in schools and there are various reasons for its use to increase teaching and learning, it is still not integrated into teaching due to instructors limited technological knowledge (Fu, 2013; Sarkar, 2012).

In another study, Kapolo (2023) examined the effectiveness of eLearning platforms in TVET within the context of Namibia. Using a mixed-methods approach, data were collected from 89 TVET trainees and six trainers through questionnaires. The study focused on the Blended Distance Learning programme implemented at Nakayale Vocational Training Centre, offering valuable insights into key elements of the eLearning process, such as user-friendly interfaces, ease of navigation, relevant infrastructure, student support systems, and capacity-building efforts. The findings highlight the suitability of eLearning platforms and the potential benefits of integrating eLearning into TVET programmes, while also identifying areas for improvement. By examining perceptions, benefits, challenges, and strategies for enhancement, the study advocates the effective integration of eLearning in TVET. Several studies, including Nyakundi (2023), Pangen and Karki (2021), and Raban and Mayisela (2024), have reported similar findings to Kapolo (2023), that eLearning is the right direction for TVET institutions in developing countries. Although eLearning holds significant potential in TVET, there remains considerable sluggishness in its implementation within institutions in developing countries, largely due to limited funding.

Taking a different angle from investigating instructors, Eiseb (2024) examined how students' habitus, based on Bourdieu's concept, influences ICT integration into the classroom. The study used open-ended questionnaires, semi-structured interviews, and written reflections to assess

the ICT-related experiences of a purposively selected group of TVET trainer diploma students from the Namibia University of Science and Technology between 2020 and 2023. Thematic content analysis revealed consistent themes across all data sources. The findings indicated that while students were generally open to using technology in teaching and learning, their initial ICT skill levels varied widely, from none to moderate competence. Those with limited skills often experienced negative emotions, such as fear, shame, and nervousness, which affected their classroom performance. These disparities were linked to differences in the quality of prior education. The study highlighted the importance of providing foundational training in digital learning tools before integrating them into teaching, emphasising that ICT skills development enhances learning quality but must address diverse starting points to avoid emotional and performance-related challenges.

In summary, the literature underscores the importance of educator competence, institutional support, and clear frameworks such as TPACK and TAM in driving effective technology integration. However, gaps remain regarding context-specific barriers and facilitators in VET, especially in low-resource settings a focus this study aims to address.

2.5 Integration of Technology into Teaching and Learning in Other Education Contexts in Namibia

Over the past few years, various research studies have been carried out in Namibia, exploring teachers' use and integration of ICT across diverse contexts. For instance, Simon et al. (2015) conducted a study to examine how Life Science teachers who had access to technology used and integrated ICT into their classroom instruction, focusing on collaborative and creative teaching practices. The study employed a qualitative research design using a multiple-case study approach. The theoretical framework guiding the study was activity theory. The study selected two Life Science teachers for observation and semi-structured interviews. The findings indicated that the Life Science teachers incorporated ICT using intelligent boards connected to eLearning management systems in their classrooms. They also collaborated by sharing notes. However, they did not co-teach or develop their teaching materials. Based on the results, the study recommends providing teachers with the necessary tools and training to create teaching materials and promoting co-teaching practices to foster collaborative teaching approaches.

Similarly, Waiganyo and Mwalengwanasho (2024) investigated the integration of ICT into secondary education in Namibia, examining both the challenges and opportunities associated with its implementation. This qualitative study used convenience sampling to select 18 teachers

from three schools. Semi-structured interviews were conducted with school principals, and group discussions involved five teachers from each school. The target population comprised teachers from Jan Jonker Afrikaner (78 employees), Jan Mohr (97 employees), and Chairman Mao Zedong (80 employees), totaling 255 staff members. The study found that ICT technologies such as projectors, Wi-Fi, smartboards, white screens, printers, and computers were used; however, teachers encountered challenges including infrastructure constraints, insufficient training and skills, instructional limitations, and resource allocation and management concerns. These findings are similar to those of Simon's (2015) study.

Moses et al. (2022) conducted a qualitative study titled *Investigating the Challenges Faced by Teachers in the Implementation of Digital Technology in Secondary Schools in Rundu Circuit, Kavango East Region, Namibia*. The study focused on the population of secondary school principals and teachers in the Rundu Circuit of Kavango East, Namibia. A sample of three principals and seven teachers from three regional secondary schools participated in the study. Data collection involved semi-structured open-ended questionnaires, and the responses were transcribed and analysed using thematic analysis. The findings revealed several barriers to implementing digital technology in teaching and learning. A significant challenge was the lack of pedagogical training for teachers. In addition, many teachers had limited or no access to digital resources available in their schools. The study also highlighted an increase in burglaries targeting computers and air conditioners, with laboratory break-ins leaving schools without essential equipment, thereby hindering the effective implementation of digital technology policies. Furthermore, some schools in the region lacked electricity, and many computers were non-functional due to the absence of technical expertise among teachers to repair them. These problems collectively undermined the integration of digital technology in the educational process.

Moses et al. (2022) and Waiganyo and Mwalengwanasho (2024) identified similar challenges teachers face when integrating technology into teaching. Waiganyo and Mwalengwanasho's (2024) study focused on schools in Windhoek, the capital city, which is assumed to be well-resourced in terms of educational infrastructure and therefore less likely to encounter significant challenges compared to schools in regions like Kavango East. However, the situation in Kavango East was exacerbated by the lack of electricity, a critical resource needed to power essential technological devices such as computers and laptops, further hindering effective technology integration.

2.6 Barriers to Technology Integration into Teaching and Learning in VET

In vocational education, obstacles to incorporating technology tend to stem from factors within the organisation and a lack of technological knowledge on the part of instructors (Cattaneo et al., 2022). The degree of support and direction the institution provides influences instructors' decisions to use technology (Antonietti et al., 2022).

Many studies on barriers to technology integration in developing countries, particularly Namibia, are in fields or contexts such as science education in primary and secondary education, and institutions of higher education other than VET. For instance, Hartley (2014) conducted a mixed-methods study to investigate the potential obstacles to integrating technology among elementary school teachers. Data collection involved the use of surveys, interviews, and focus groups. The study used the Concerns-Based Adoption Model developed by Hall and Hord (2001) to gauge teachers' perceptions of technology integration. The researcher obtained qualitative data from eight teachers selected from the school district, in northern Genesee County, Michigan. Quantitative data were analysed using descriptive statistics, and qualitative data were coded to identify emerging themes. The findings indicated the existence of four barriers to integrating technology into daily classroom lessons. These barriers included a) insufficient training and technical support, b) lack of prioritisation and support from administrators, c) limited resource allocation and convenience, and d) challenges in reducing teacher workload.

Moreover, Tarman et al. (2019) found barriers in their study to explore the perspectives of Turkish social studies teachers regarding the obstacles to integrating technology into the teaching and learning process. The researchers used a quantitative survey approach and distributed a 34-item questionnaire to 171 social studies teachers in Turkey. The results revealed that the barriers most identified by the teachers were primarily external factors as they did not have control over them including inadequate technology availability, limited internet access, and insufficient administrative and technical support. Furthermore, the study found no significant differences in the perceived barriers between female and male teachers. However, the study identified a statistically significant difference between teachers who participated in technology-related professional development and those who did not. As revealed in the study by Hartley (2014), insufficient training and limited resource allocation are generally seen as challenges, yet they can also present opportunities for growth and development for TVET teachers. For instance, scarce resources compel teachers to be creative, devising innovative

methods to teach and involving students using minimal tools. This might include utilising locally sourced or recycled materials for hands-on activities rather than depending on costly equipment. In terms of insufficient training, teachers are inspired to pursue further learning opportunities, such as participating in online courses, attending workshops, or collaborating with peers. They may also engage in communities of practice or take advantage of free online platforms to enhance their skills.

Kundu et al. (2020) concurred with Tarman et al. (2019), adding that internal factors that could serve as barriers to technology integration are low teacher self-efficacy, teacher attitudes and acceptance, and teacher perceptions. Moreover, researchers such as Hu et al. (2019) and Sert (2021) argued that a lack of adequate and continuous professional development inhibits the use and integration of technology into the classroom. Researchers such as Ghavifekr et al. (2016) have noted that many instructors find it challenging to develop competencies with new tools and practices, which become a barrier for them to incorporate into their teachings. While professional development opportunities for instructors aim to enhance technology use and integration, they do not always result in the actual incorporation of technology into teaching practices.

In another study, Halim and Hashim (2019) examined teachers' perceived barriers to technology integration related to 21st-century learning goals. The study adopted a qualitative case study approach guided by a conceptual framework examining the connection between the digital divide and students' learning. The study used an open-ended questionnaire from 23 elementary school teachers at a local school district to gather data and address the research problem. In addition, six of these teachers participated in interviews. Data analysis used constant comparative analysis. The findings revealed that teachers identified a shortage of technology resources, which hindered students' access to technology as the main barrier to integrating technology in the classroom. As a result of these findings, teachers introduced a programme to enable students to bring their own technologies to school.

Likewise, Al Gamd et al.'s (2016) study investigated the challenges of adopting eLearning in higher education by focusing on a recently established Saudi university as a case study. The study used 214 questionnaires to collect quantitative data. The quantitative data analysis revealed several barriers from external sources, such as poor internet access, networking problems, limited training on eLearning, lack of technical support, and inadequate hardware and software, were the most reported barriers that hindered the effective implementation of

eLearning at the specific Saudi university under investigation. In addition, internal barriers, including fear of technology, concerns about the quality of e-courses, lack of role models, and security concerns, further contributed to the challenges faced by the university in implementing eLearning. The study findings further indicated that these barriers were largely gender related.

Most of the barriers identified in the studies mentioned above are similar and likely have comparable implications for technology integration. A significant limitation is that these barriers may prevent teachers from effectively incorporating technology into their teaching practices. Barriers such as insufficient funding and resource constraints can significantly hinder equitable access to technology, particularly in underfunded institutions or schools. Thus, addressing these challenges requires substantial investments in infrastructure, hardware, and software, coupled with strategies to ensure that these resources are readily accessible to teachers. Notably, none of these respective studies, except for Halim and Hashim (2019), have proposed strategies or solutions for overcoming barriers to technology integration. Halim and Hashim's participants addressed the shortage of technologies by allowing students to bring their own technologies to school.

Other studies identified a range of factors or barriers to technology integration that are more teacher-specific and not directly tied to technologies. For instance, Blackwell et al. (2014) conducted a study employing path modeling to examine the correlation between extrinsic and intrinsic factors that impacted foundation years educators' use of digital technology. Survey data collected from 1 234 foundation years educators were analysed. Confidence in using technology and the support received in using it also plays a substantial role. Moreover, student socioeconomic status had the most significant impact on attitudes, while support and technology policy affected teacher confidence, which, in turn, influenced attitudes. Interestingly, the study revealed that more experienced teachers tended to have more negative attitudes towards technology.

Lawrence et al. (2018) and Xiao et al. (2019) noted that personal factors such as teacher level, time, experience, school teaching level, and the level of technology integration in teaching and learning, and professional factors such as tenure, training, and workshops, were the primary factors influencing technology integration in the classroom. In addition, other aspects such as individual characteristics like communication skills, creativity, and leadership abilities among others, technological skills, organisational situations, such as decision-making hierarchies, cross-functional teams or project-based teams, and content characteristics, such as highly

specialised knowledge and practical, hands-on applications also influenced or inhibited the effective use of ICTs (Shirish et al., 2021).

Nortvig et al. (2018) reviewed factors that impact learning experiences in professional bachelor education and teacher training, specifically in eLearning, online learning, and blended learning. The research papers included in the review revealed that certain factors tended to have more prominence. These factors included the presence of educators in online settings, interactions among students, teachers, and content, intentional connections between online and offline activities, and campus-related and practice-related activities such as simulation, internships, field trips, and group projects. The article highlights these significant factors while discussing and questioning the relevance of research that solely compares different formats of eLearning, online learning, blended learning, and traditional face-to-face teaching. The review acknowledges that teaching and learning are complex processes influenced by various factors beyond the instructional format. The study reviewed systematic database searches conducted in January 2017, encompassing 44 peer-reviewed articles and papers published between 2014 and 2016.

Despite all the challenges identified in the studies above, research on classroom technology use highlights significant progress in addressing barriers to technology integration, particularly regarding access to computing resources. For instance, Johnson et al. (2016) recommended several strategies to overcome first-order (external) barriers, including: 1) securing funding through non-traditional means, such as crowdfunding and grants; 2) leveraging guidance from the International Society for Technology in Education to identify effective professional development programmes; 3) using the expertise of master teachers in professional learning communities (PLCs); 4) arranging training sessions with software companies for newly adopted educational tools, and 5) ensuring robust technical, administrative, and peer support for teachers during implementation. However, addressing second-order (internal) barriers related to teachers' attitudes, beliefs, skills, and knowledge poses a greater challenge. Suggestions to overcome these internal barriers include: 1) offering teacher training programmes that emphasise constructivist, student-centred education; 2) directing professional development efforts towards integrating technology into instruction rather than administrative tasks; 3) incorporating visualisation tools in student tracking systems to help teachers easily interpret student progress; 4) actively involving teachers in the decision-making process when adopting new technologies, and 5) providing training that integrates TPACK. Barton and Dexter (2020), Durff and Carter (2019) concur with Johnson et al. (2016) that addressing

barriers to technology integration requires a comprehensive focus on key areas such as improving infrastructure, providing necessary tools, fostering positive pedagogical beliefs, enhancing teacher self-efficacy and skills, promoting effective ICT use, encouraging innovation and investing in professional development.

2.7 Technological Pedagogical Content Knowledge in Teaching and Learning

This section introduces TPACK as teacher knowledge in instruction, emphasising the integration of technology with pedagogy and content. The concept of TPACK is primarily built on three core knowledge domains. The first two are CK and PK, as outlined by Shulman (1987). The third domain is technological knowledge, which refers to the knowledge teachers need to effectively use technology. These three domains intersect and integrate, with an overlap between CK and PK. Furthermore, the interactions between TK, PK, and CK also give rise to distinct forms of knowledge, including TPK, technological content knowledge, and PCK. Therefore, for TVET teachers, having TPACK signifies the ability to significantly improve teaching by integrating technology effectively.

Numerous researchers have studied TPACK in teaching and learning. For instance, Koh et al. (2010) conducted a study examining the TPACK of Singapore pre-service teachers with a large-scale survey. The research offered the characteristics of pre-service teachers in Singapore in terms of their TPACK. Through an exploratory factor analysis, the study identified five distinct constructs: technological knowledge, CK, PK as the general teaching practices, knowledge of teaching with technology as the knowledge to integrate technology into those teaching practices, and knowledge derived from critical reflection. Interestingly, the participants did not distinguish between different TPACK constructs, such as TK and CK, and pedagogical expertise. This was because they struggled to understand the connections between technological content knowledge and technological pedagogical knowledge, and how these constructs are interrelated, as highlighted by Qiu et al. (2022). Some variations in TPACK perceptions were observed based on gender, but age and teaching level did not significantly influence them.

In agreement with Koh et al.'s (2010) results, Knolton's (2014) study in the Midwest examined the potential connection between TPACK, pedagogical training, and personal technological devices and found notable connections between pedagogical training and the choice of suitable technology and between personal technology usage and the selection of appropriate technology. Furthermore, the data highlighted the TPACK as a predictor of which technological

tools to use in classrooms. However, the study found that the effects of different parts of TPACK were unclear because there was a lot of overlap or interaction between them. It is noteworthy that while connections were identified between the knowledge domains, their overlaps may have posed barriers to effective understanding which may affect the integration of technology into teaching. Koehler et al. (2014) state that the TPACK framework highlights the interplay between teachers' knowledge of content, pedagogy, and technology, demonstrating how these areas interact to facilitate effective teaching practices. Similarly, Chen (2024) emphasises that the TPACK framework posits that teachers must possess a comprehensive understanding of content, pedagogy, and technology to effectively integrate these elements into their teaching practices.

In another study, Bwalya and Rutegwa (2023) determined whether the confidence of pre-service science and mathematics teachers in integrating technology into their teaching was influenced by their beliefs and attitudes toward technology integration. Through a cross-sectional survey design, the study compared the self-efficacy of TPACK among 202 pre-service science and mathematics teachers from two universities in Zambia. The data analysed using the independent samples t-test and the one-way ANOVA revealed that pre-service teachers possessed a moderate level of TPACK self-efficacy and that there was no statistically significant difference in self-efficacy between student teachers from the two universities ($t[200] = 2.11, p = .83$). A study by Koh et al. (2010) made the same observation in terms of gender. However, age and teaching level did not significantly influence technology integration.

Koehler and Mishra (2009, p. 67):

The TPACK framework emphasises effective teaching with technology through understanding how to represent concepts using technology, employing pedagogical techniques that leverage technology to teach content constructively, and recognising how technology can address learning challenges by making concepts easier to grasp for students.

Therefore, TPACK allows instructors to determine what knowledge is required to integrate technology into teaching and how they are supposed to develop such expertise within themselves (Chaipidech et al., 2021; Guggemos et al., 2021; Shafie et al., 2019). Instructors' knowledge of integrating content, pedagogy, and technology has become vital because it makes the teaching and learning process more activity-oriented, with students taking charge of their learning by being active and inquiry-based (Wasriep et al., 2019). Therefore, a combination of TPACK is required for teaching with technology (Altun, 2019; Deng et al., 2017).

Few studies on TPACK within the VET context globally exist, including Nurhadi et al. (2018), surveyed to determine the TPACK of teacher candidates for vocational high schools in Indonesia and to map it by its data collection using a survey research method and a quantitative approach. Focusing on students aspiring to become teachers and enrolled in the Faculty of Engineering at the State University of Malang, the study collected data from 200 respondents selected using a stratified random sampling method. The findings indicated that potential vocational high school teachers generally possessed moderate TPK. However, the study did not reveal the reasons for such a moderate level of TPACK among these teachers. In this sense, Koehler et al. (2014) emphasise that the TPACK framework proposes that teachers must possess a thorough understanding of each of the key knowledge components to effectively integrate and harmonise technology, pedagogy, and content into their teaching practices. Therefore, to enhance their abilities to use technology effectively for teaching and learning in line with the demands of the fourth industrial revolution (4IR), the study recommended that it was crucial to develop educational courses for teacher candidates. These educational courses, such as the educational technology course International Computer Driving, enable teachers to make the most of technological tools in their instructional practices and align them with the relevant content and pedagogies. The 4IR is relevant to this study because it emphasises the transformative impact of advanced technologies such as Artificial Intelligence, IoT, and robotics on education. Fostering digital literacy and adopting innovative teaching methods, 4IR prepares students for a workforce driven by technology (Muzuva, 2024). This is especially relevant for VET, as it ensures both TVET teachers and students gain the skills needed to thrive in industries increasingly influenced by automation. Research in this field explores how educational practices can evolve to incorporate 4IR technologies, addressing the shift from traditional approaches to meet the demands of the modern workforce (Oke & Fernandes, 2020).

The TPACK framework is context dependant and may not be suitable to all contexts and TVET is not excluded. However, studies done in that regard indicate otherwise. For example, Mbele (2021) investigated and identified an appropriate technology integration framework within the TVET sector. A qualitative approach employing an action research paradigm was used to explore the contemporary phenomenon of technology integration by TVET college lecturers. Purposive or judgemental sampling was employed to select participants who were interviewed through focus group discussions. A TPACK framework was employed as a guiding framework for technology integration within the TVET sector. The study's findings indicate that educators perceived the TPACK framework as enhancing teaching methods and fostering a student-

centred approach. Data analysis of participants' responses revealed that out of 74 sub-themes identified, the 'improved teaching and learning' theme accounted for 30 sub-themes, contributing 40%, while the 'student-centred learning' theme contributed 28 sub-themes, representing 38%. The study emphasises a technology teaching expert-led development approach within the TVET sector, where a specialised expert collaborates with a select group of lecturers to support the development of TPACK.

Similar results were found in an earlier study by Naziri et al. (2019) who highlighted the need for the TPACK element in clinical supervision among Design and Technology teachers during the classroom teaching process. The study sampled senior technical and vocational subject teachers from 484 participants in the state of Melaka. A quantitative approach was employed, using random sampling and a questionnaire for data collection. The findings revealed that the CK element scored the lowest mean within the pedagogical technology knowledge component. Meanwhile, technological knowledge, PK, content pedagogy knowledge, content technology knowledge, and content pedagogy technology were deemed essential in the supervision process for these teachers. Teachers' challenges in enhancing their technological competence, knowledge, and teaching skills are identified as crucial to meeting the evolving needs of senior technical and vocational subjects and achieving a higher level of professionalism.

In addition, Torggler et al. (2023) adapted the TPACK framework for VET teachers in Germany. The study reviewed scholarly articles from literature databases such as the Literaturdatenbank Berufliche Bildung and Web of Science, including journals indexed in the Social Sciences Citation Index. The findings indicated that after analysing the requirements of the VET system in Germany within the context of digitalisation, it was suggested to adapt and expand the existing TPACK framework, creating an N-TPACK framework. This framework incorporates "networking and collaborative knowledge" as a crucial component of VET teachers' professional knowledge.

The studies mentioned above share similarities in focus and scope; for example, Mbele (2021) adapted the TPACK framework as outlined by Koehler and Mishra (2006, 2009), though for specific reasons. In contrast, Nazir et al. (2019) modified the TPCK to pedagogical technology CK due to high scores of pedagogical technological knowledge in relation to technological content knowledge. Likewise, Torggler et al. (2023) modified the TPACK framework to better align with TVET, incorporating the findings on how TVET teachers engage in networking and collaboration within the field. Literature indicates that while some scholars have applied the

TPACK framework as originally designed, others, such as Nazir et al. (2019) and Torggler et al. (2023) argue that the original TPACK framework may not be suitable for TVET. As a result, these researchers have modified the framework to better align with the work and practices specific to TVET. Koehler et al. (2014) highlight that the TPACK framework is not isolated but is rooted and applied within specific contexts.

2.8 TPACK Development of Teachers in Teaching and Learning

The introduction of TPACK as a framework for comprehending the PK necessary for integrating technology has sparked a flurry of scholarly investigation (Foulger et al., 2022; Makinster & Trautmann, 2014). Up until this point in time, TPACK development has received the attention of about 500 publications and presentations since its development in 2005 (Crosthwaite et al., 2021). However, scholars have shifted their attention from understanding TPACK as a construct and how it is used in teachers' planning and instructional activities (Zou et al., 2022) towards specific methods aimed at aiding future and practicing teachers in developing their TPACK.

Several studies were undertaken to examine how TPACK is developed by teachers from all walks of life. For instance, Jiménez Sierra et al.'s (2023) study explored emerging trends associated with the development of TPACK through lesson studies in Spain. The study used descriptive content analysis to examine and structure qualitative and quantitative studies in 16 papers published between 2015 and 2021. The survey results revealed that lesson studies and microteaching fostered teachers' TPACK development. The approaches entail teachers working collaboratively to devise solutions for teaching and learning challenges within a specific educational context. Further, research has linked the development of TPACK to the integrative viewpoint described by Mishra and Koehler (2006). This perspective involves the fusion of PK, technological knowledge, and CK into distinct elements: PCK, TCK, and TPK. These elements emerge because of the interactions between pedagogy and content, technology and content, and technology and pedagogy. However, the study noted that different elements of TPACK are developed separately but integrated during classroom teaching; for example, the Pedagogical Knowledge component is created primarily through conversations and reflective situations, as these are inherent aspects of pedagogy and are integral to a teacher's role from the outset.

In addition, Hofer and Grandgenett (2012) noted that prospective teachers develop their TPACK through individual courses and integrated strategies incorporating technology into

teacher training programmes. The study was conducted at Mid-Atlantic University to provide insight into how the TPACK develops in a typical three-semester teacher preparation programme. The study also reaffirmed that the different components of TPACK might not necessarily develop simultaneously or follow identical development pathways. Hence, teachers viewed self-initiated learning through individual courses and teacher training as important sources of their TPACK development.

Major and McDonald (2021) echo the perspective of Hofer and Grandgenett (2012) by emphasising the importance of integrating research on TPACK development. They provide a comprehensive overview of recent studies over the past decade, focusing on interventions aimed at supporting educators in enhancing their TPACK capabilities in the USA. The study reviewed 13 peer-reviewed and published articles to identify practices related to improved TPACK among university instructors. The results showed that enhancing educators' TPACK can be achieved through a variety of means, including instructional consultations such as modelling, pedagogical realignment, and encouragement to practice, the train-the-trainer approach and online training courses as part of professional development, scaffolding, and extended, distributed training programmes. The study highlights that TPACK is not only developed in action but also employs several strategies such as regular workshops and training, exchange of ideas and experiences with colleagues, and continuous learning to enhance TPACK, to pave the way for instructors to acquire knowledge and develop TPACK. This insight is crucial as it highlights that TPACK is not solely developed during teaching but also emerges through various other activities.

Voogt and McKenney (2017) examined if and how five teacher education institutes assist students in cultivating the essential PCK required for using technology in early literacy education in the Netherlands. The study conducted focus group discussions with 12 teacher educators. The study found that teacher education institutions allocated minimal time to instructing technology applications that substantially benefited early literacy teachers within their existing curriculum. However, the institutions acknowledged the importance of incorporating technology into the early literacy curriculum. This marks a recent advancement in the literature concerning the impact of time on TPACK development.

Few studies on TPACK development in teaching and learning exist in VET. For instance, Imansaria et al. (2020) studied the syntax of TPACK development through blended learning for the learning planning course for vocational teacher candidates in Indonesia. The study used

a 4D model that consisted of defining, designing, developing, and disseminating to foster TPACK development involving blended learning, which combines online and in-person instruction. Consequently, researchers formulated a structured TPACK development approach using blended learning comprising four stages: recognition, building foundational knowledge, instructional tools, and synthesis. The validation results confirmed that the TPACK development process via blended learning received an “excellent” rating and was well-suited for university-level learning.

Table 2.1: A summary of literature used to demonstrate technology integration and TPACK development from 2010–2022

Researchers	Country	Population	Measuring	Methodology & Theoretical Framework
Dewi et al. (2021)	Turkey and United States	16 articles	TPACK evaluation	Systematic review
Hartley (2014)	Michigan	100 Elementary teachers	Technology integration	Mixed-methods study (surveys, interviews, and focus groups)
Hofer and Grandgenett (2012)	United States	Prospective teachers with baccalaureate degrees	TPACK evaluation	Descriptive study (mixed-methods)
Imansaria et al. (2020)	Indonesia	Vocational teacher candidates	Group TPACK	The 4D model consisted of defining, designing, developing and disseminating to foster TPACK development
Kapolo (2024)	Namibia	89 TVET trainees and six trainers	TPACK	Mixed-methods, questionnaire
Kanbul et al. (2022)	Nigeria	Technical and vocational education (TVE) teachers in six colleges of education	TPACK competence	Quantitative approach (60 questionnaires) TPACK model
Knolton (2014)	United States	30 adjunct faculty members	TPACK development	Quantitative pre-experimental static group

Koh et al. (2010)	Singapore	Pre-service teachers	Group TPACK proficiency	Survey
Major and McDonald (2021)	USA	Educators	Group TPACK	Reviewed 13 peer-reviewed and published articles
Moses et al. (2022)	Namibia	Three principals, seven teachers and	Technology acceptance model	Semi-structured open-ended questionnaire
Mbele (2021)	South Africa	TVET college lecturers	TPACK	Qualitative, focus group
Naziri et al. (2019)	Malaysia	484 instructors	TPACK	Quantitative, questionnaire
Nurhadi et al. (2018)	Indonesia	200 respondents	TPACK evaluation	Quantitative approach (survey research method)
O'Brien (2015)	Australia	19 teachers	TPACK teachers' knowledge and beliefs	Mixed-methods approach (pragmatism paradigm, survey questionnaires, semi-structured interviews)
Polikarpus et al. (2023)	Estonia	146 trainers	Technology integration	Survey
Ramadan et al. (2018)	Sudan	200 respondents	Technology integration	Quantitative approach
Richard et al. (2023)	Ghana	152 art teachers	Technology integration	Quantitative research, online survey instrument
Sánchez-Prieto et al. (2020)	Spain	1 568 teachers	Technology integration	Quantitative (descriptive methods, questionnaire)
Simon et al. (2015)	Namibia	Two Life Science teachers	Technology integration	Qualitative (research design, multiple-case study approach, observation, and semi-structured interviews)
Summak et al. (2011)	Turkey	VET teachers	Technology integration	Quantitative (descriptive method, 500 questionnaires)

Tarman et al. (2019)	Turkey	171 social studies teachers	TPACK perspectives	Quantitative (survey approach, 34-item questionnaire)
Torggler et al. (2023)	Germany	Scholarly articles	TPACK	Systematic review
Uandara (2023)	Namibia	11 TVET instructors	Technology acceptance model	Semi-structured interviews and focus group
Voogt and McKenney (2017)	Netherlands	12 teacher educators	Group TPACK	Focus group
Waiganyo and Mwalengwanasho (2024)	Namibia	18 teachers	Technology acceptance model	Qualitative, semi-structured interviews and focus group

As seen in Table 2.1, most African studies (e.g., Mbele, 2021; Kapolo, 2024, Moses et al., 2022; Richard et al., 2023; Simon et al., 2015; Uandara, 2023; Waiganyo and Mwalengwanasho (2024) rely on qualitative methods, suggesting a need for more quantitative validation. However, most studies from the Global North (e.g., Nurhadi et al. 2018; Naziri et al. (2019); Tarman et al., 2019; Ramadan et al., 2018) rely on quantitative methods suggesting a need for more quantitative validation.

Collectively, these studies suggest that TPACK development is multi-faceted and context-dependent. Future efforts should focus on integrating these strategies into VET teacher training programs, which remain underexplored.

2.9 Knowledge Gaps in the Reviewed Literature

In this chapter, I presented a literature review related to the study. The reviewed literature explored how school teachers, university lecturers and educators, and TVET teachers integrated technology into primary and secondary education in institutions of higher learning and VET classrooms. While TPACK holds significance in incorporating technology into vocational education, several aspects of the literature review warrant critical evaluation.

While many studies have explored technology integration into teaching, only a few of these specifically focused on how TVET teachers integrate technology into VET classrooms. Therefore, the literature overwhelmingly supports the evolution of TPACK in VET, highlighting the need for alignment with existing research.

The literature review demonstrates a comprehensive coverage of relevant studies in the field, including various sources, such as academic journals, conference proceedings, and reports, and enhances the depth and breadth of the review, providing a robust understanding of how instructors integrate technology into VET classrooms. Moreover, there is a comprehensive understanding of VET, how it operates, why countries develop their VET systems and the challenges they experience. Studies (Ayonmike et al., 2015; Autor, 2014; Alagaraja et al., 2014; Baumgarten et al., 2016; Guo et al., 2020; Hashim et al., 2022; Pongo et al., 2015) have extensively studied VET in Africa and beyond. In addition, the matter of TPACK has been studied in different contexts, such as in professional teacher development (Fahrurrozi et al., 2019), TPACK in general (Dewi et al., 2021; Koh et al., 2010; Koehler & Mishra, 2009; Knolton, 2014; Nurhadi et al., 2018), and pre-service science and mathematics teachers (Bwalya et al., 2023). Furthermore, several studies on technology integration exist across the world. For example, on the knowledge and beliefs about technology integration (O'Brien, 2015; Polikarpus et al., 2023), technology integration in VET and other contexts (Eiseb, 2024; Fu, 2013; Kapolo, 2023; Kambul et al., 2022; Koskinen et al., 2018; Moses et al., 2022; Ramadan et al., 2018; Rathore et al., 2015; Richard et al., 2023; Sánchez-Prieto et al., 2020; Sarkar, 2012; Scoular et al., 2018; Simon et al., 2015; Summak et al., 2011; Szymkowiak et al., 2021; Taimalu et al., 2019; Tajpour et al., 2022; Uandara, 2023; Waiganyo & Mwalengwanasho, 2024), barriers to technology integration (Al Gamad et al., 2016; Blackwell et al., 2014; Hartley, 2014; Halim et al., 2019; Hu et al., 2019; Johnson et al., 2016; Kundu et al., 2020; Lawrence et al., 2018; Nortvig et al., 2018; Tarman et al., 2019; Xiao et al., 2019) and TPACK development in teaching and learning (Hofer & Grandgenett, 2012; Imansaria et al., 2020; Jiménez Sierra et al., 2023; Major & McDonald, 2021; Voogt & McKenney, 2017;).

In addition, the literature review also establishes clear research objectives and questions which contributed to the focus and coherence of the evaluation. The authors explicitly stated their aims to explore technology integration in VET and other contexts, providing a solid foundation for the subsequent analysis. Moreover, the review effectively synthesises the findings from the selected studies, which led to the categorisation of literature based on researchers or authors, country, population, measuring, methodology, and theoretical frameworks to allow for a logical organisation of information and enable readers to navigate through the review quickly. Furthermore, the review includes a critical evaluation of the methodologies employed in the included studies, which shows that most studies reviewed adopted quantitative research designs, with few using systematic reviews of journal articles and a mixed approach design.

Most studies also used random sampling to select participants and mostly used questionnaires to collect data.

Although there is substantial evidence of studies on technology integration into VET globally, which provide a comprehensive overview of the evolution of TPACK in VET, they need to address several gaps. Most of these studies were undertaken elsewhere, such as in Estonia, Nigeria, Australia, Malaysia, Turkey, the USA, Sudan, Indonesia, the Philippines, and Korea. Again, the studies on TPACK in Namibia focused on other fields and contexts such as science, mathematics, and assessment during teachers' pre-service and primary and secondary education other than VET. While those studies on TPACK in TVET focused on teachers' perspectives and perceptions and factors influencing technology integration none focused on TVET teachers' technology integration and development of TPACK. This then created a research gap that needs to be filled by the current study. Moreover, other gaps included adopting a quantitative research design in most studies, using random sampling only, and using a questionnaire or research survey. Therefore, in addressing these gaps, this study adopted a qualitative multi-case study research design and used other instruments such as interviews, focus group discussion, and non-participatory observation for data collection. Further, the study used purposive sampling to select participants. The study aimed to understand how TVET teachers develop their knowledge of teaching with technology so that it could help support a deeper fusing of technology with vocational education and learning in Namibia.

2.10 Chapter Summary

This chapter examined the literature relevant to this study using an SLR because it involves more rigorous review methods, offering complete coverage of all the evidence published. It investigated the integration of technology into teaching by VET instructors. Subsequently, the review concentrated on an overview of VET, technology integration in teaching and learning in VET, barriers to technology integration into teaching and learning in VET, TPACK in VET, and the development of TPACK in teaching and learning. The development and prosperity of a nation's economy and society are contingent upon the skills and knowledge possessed by its populace. In recent years, there has been a growing recognition of the significance of VET owing to transformations within various sectors of the economy. The study adopted a UNESCO definition of VET, a comprehensive concept in education that extends beyond traditional academics, encompassing the study of technologies, related sciences, practical skills, attitudes, understanding, and knowledge applicable to various aspects of economic and social life. As

the education systems get infused with technology and students are exposed to technologies, teachers need to acquire technological knowledge and the VET sector is no exception to using technology.

Further, VET instructors need to integrate technology into teaching in alignment with content and pedagogy. However, they lack the knowledge of technological pedagogical content to do so. In addition, the instructors' perspectives, attitudes, and beliefs play a role in technology integration. Technology integration improves student' mastery of concepts, student achievements, and effective teaching. However, technology integration faces obstacles such as inadequate technological infrastructure, poor internet connectivity, lack of technological knowledge, low teacher self-efficacy, and teacher attitudes and acceptance. Some studies also noted barriers regarding age, gender, and qualifications that hinder technology integration. The significance of educators possessing the expertise to blend content, teaching methods, and technology has grown as it promotes an interactive and student-driven approach to teaching and learning.

Consequently, the effective use of technology in education necessitates a fusion of technological know-how, pedagogical skills, and CK, commonly referred to as TPACK. There is extensive research on the development of TPACK in teaching and learning. Institutions have used various strategies such as lesson studies, microteaching, individual courses, modeling, and providing professional development. However, teachers cannot develop TPACK elements together as it depends on the individual and the type of knowledge lacking. Although extensive research on technology integration exists, the concentration is mainly in Europe, Asia, and Africa. Also, the focus is primarily on pre-services, science, and mathematics in secondary education. In addition, there is limited literature on technology integration in TVET, particularly in developing countries such as Namibia.

This literature review reveals critical knowledge and methodological gaps in understanding how TVET instructors in Namibia develop and apply TPACK, thereby informing the study's qualitative, multi-case research design.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

In the previous chapter, I reviewed the related literature. The chapter provided an overview of the SLR adopted to review past journal articles on technology integration research. The literature reviewed included an overview of VET, the integration of technology into teaching and learning in VET, the integration of technology into teaching and learning in other contexts, barriers to technology integration into teaching and learning in VET, TPACK in teaching and learning, and TPACK development in teaching and learning. The chapter also provided a literature critique, highlighting the gaps and discussing how this study closes those gaps.

This chapter provides the theories used to guide and solidify the study that served as lenses for data analysis. These theories served as foundations to construct knowledge that would answer this study's research questions. A theoretical framework is a structure that outlines the fundamental concepts, theories, assumptions, and variables relevant to a particular research project or study (Imenda, 2014). According to Stylianides and Stylianides (2009), a theoretical framework helps researchers validate arguments and justify what has been found and concluded. Another critical aspect of the theoretical framework is the provision of lenses through which researchers focus on their data and see the meanings embedded in the data (Osanloo & Grant, 2016), and this leads to the data analysis being strengthened by making references to theories (Yang & Jiang, 2014). Therefore, this study leveraged the components of the TPACK framework and the SDL theory as guiding frameworks to ensure alignment between the study's objectives, research questions, and methodology. The TPACK framework was used to evaluate TVET teachers' knowledge and their role in facilitating effective technology integration. In addition, the SDL theory was employed to explore how TVET instructors independently develop strategies for integrating technology into their teaching, ultimately enhancing teaching practices and outcomes. The chapter is structured as follows: first, the chapter explores the overview of each framework, starting with TPACK and then SDL. This is followed by the justification of adopting each theory including acknowledgement of some of their limitations. Second, the chapter highlights the combined theoretical frameworks (TPACK and SDL) by discussing the conceptual framework created. Lastly, the chapter concludes with a summary of the discussion.

3.2 Theoretical Frameworks

The theoretical frameworks adopted for this study were the TPACK framework and SDL theory, which explain how TVET teachers integrate technology into teaching and develop TPACK.

3.2.1 TPACK framework

Mishra and Koehler (2006) developed the TPACK framework to understand the knowledge domain required to integrate technologies into teaching effectively. The framework results from the Pedagogical Content Knowledge (PCK) model developed by Shulman. The PCK model suggests that teachers possess the CK (subject matter) and the PK (teaching methods) to deliver instructions. Koehler and Mishra (2006) point out that TPACK is developed and shaped by myriad contexts such as teachers, students, and the learning environment. Consequently, understanding the TPACK framework would allow me to explore how instructors integrate technology into the content and pedagogy in their classrooms to aid students in learning more effectively. Through TPACK, TVET teachers can plan their lessons to deliver specific content via specific teaching methods supported by certain technological tools to help students learn. Hence, TVET teachers can use the TPACK framework as an effective tool to integrate technology, pedagogy, and content into teaching, helping TVET teachers master technology and apply it effectively in their teaching and learning processes (Mishra & Koehler, 2006; Schoen & Fusarelli, 2008).

The foundation of this framework lies in recognising that effective teaching cannot happen unless there is a balanced intersection of three knowledge domains: technology, pedagogy, and content (Wasilko, 2020; Khene et al., 2021). In this study, the TPACK framework enabled a thorough analysis of teachers' current knowledge structures and the intricate interplay between their technological, pedagogical, and content knowledge. Mishra and Koehler (2006) further explain that although several models/frameworks exist to incorporate technology into teaching and learning, the TPACK framework has received the most attention in research and professional development approaches, hence its wide usage.

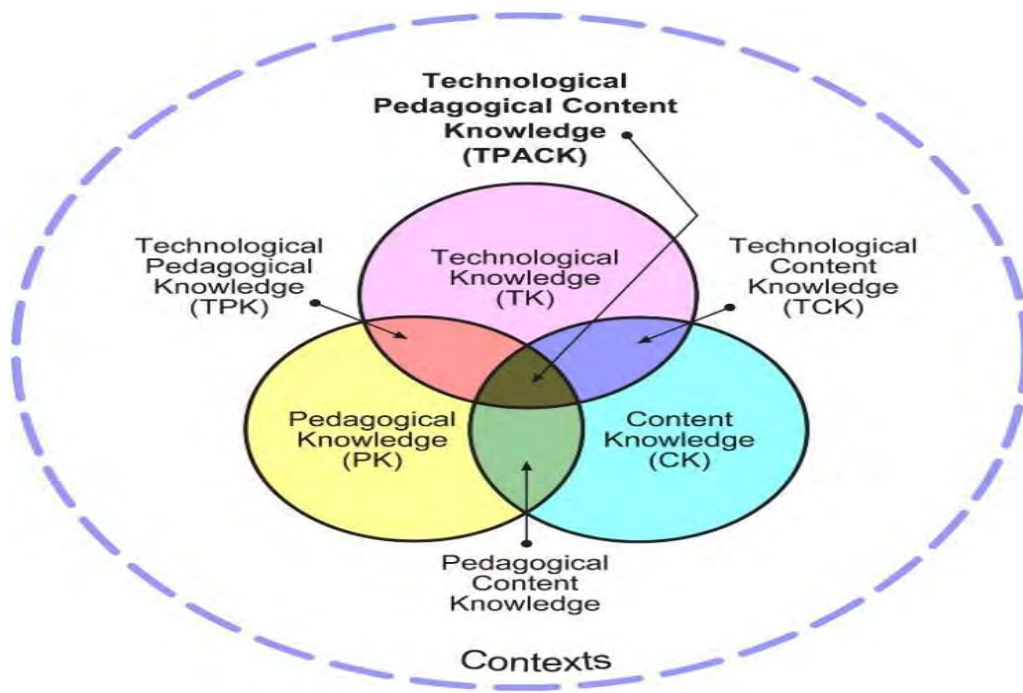


Figure 3.1: The TPACK framework

Source: <http://tpack.org>

The TPACK framework, as discussed by Fahrurrozi et al. (2019), is comprised of seven elements (See Figure 3.2), where the first three (TK, PK & CK) form the foundation and the rest (Technological Content Knowledge [TCK], Technological Pedagogical Knowledge [TPK], PCK & TPACK) explain the interaction and relation between them (Mishra & Koehler, 2006). The study adopted all seven elements of the TPACK framework as described below:

- Technological Knowledge

According to Kara (2020), technological knowledge refers to the understanding and expertise of individuals, organisations, or societies in technology and its applications. It encompasses various knowledge, skills, and capabilities related to various technological tools, processes, methods, and systems.

- Content Knowledge

Content Knowledge (CK) refers to the depth and breadth of understanding of a specific subject or field. According to Shulman (1986), this knowledge encompasses concepts, theories, notions, structural frameworks, substantiation, validation, and established procedures and methods for constructing such knowledge. For this study, this is the subject knowledge, for

example, carpentry, auto mechanic, or electrician, that TVET teachers have acquired throughout their training and aim to impart to their students. Therefore, TVET teachers can only teach if they know and understand their subject. This understanding agrees with the notion of Mishra and Koehler (2006) that teachers must know and understand their subjects, including knowledge of concepts, theories, and established procedures and methods in that field.

- Pedagogical Knowledge

Pedagogical Knowledge (PK) refers to understanding instructional strategies and methods that educators possess about the art and science of teaching and learning (Kind & Chan, 2019). It involves knowledge about effective classroom management techniques and the ability to adapt teaching methods to meet the diverse needs of learners. TVET teachers would then be able to develop teaching strategies relevant to the content in the VET classroom. In this instance, TVET teachers with an in-depth understanding of PK know precisely how students acquire knowledge and skills and develop positive attitudes toward their learning (Mishra & Koehler, 2006). Therefore, it supports and enables TVET teachers to deliver their content in the VET classroom.

- Pedagogical Content Knowledge

Pedagogical Content Knowledge (PCK) is a specialised form of knowledge that combines both CK and PK to effectively teach a specific subject or content area (Kind & Chan, 2019). At the core of Shulman's understanding of PCK is the idea of reshaping the subject matter to make it suitable for teaching. According to Shulman (1986), this reshaping occurs when the teacher interprets subject matter, discovers various methods of presenting it, and adjusts and customises the teaching materials to suit different interpretations and the student's prior knowledge. This knowledge would enable TVET teachers to design effective teaching and learning strategies.

- Technological Content Knowledge

Technological Content Knowledge [TCK] refers to a unique blend of technological knowledge and CK that enables the effective delivery of subject matter using technology (Santos & Castro, 2021). It represents comprehending how technology and content interact and limit each other. TVET teachers possessing this knowledge would be able to know which technological tools suit teaching which content and create a balance between them. At this point, TVET teachers

would consider the affordances and constraints of the technology they plan to use in their classrooms.

- Technological Pedagogical Knowledge

Technological Pedagogical Knowledge (TPK) is a specific type of knowledge that emphasises the seamless integration of technological knowledge with PK to enhance teaching practices in educational environments (Mulyadi et al., 2020). Technological Pedagogical Knowledge (TPK) includes TVET teachers' knowledge of the pedagogical affordances and constraints of various technological tools related to disciplinarily and developmentally appropriate pedagogical designs and strategies.

- Technological Pedagogical Content Knowledge (TPACK)

TPACK is a comprehensive framework that integrates three essential components of teaching and learning: technological knowledge, PK, and CK (Santos & Castro, 2021). This understanding emerges from interactions among content, pedagogy, and technology knowledge.

TVET teachers need to be aware of all seven knowledge domains of TPACK when planning to integrate technology into their lessons. Moreover, TPACK urges TVET teachers to possess knowledge of the affordances and constraints that come with technology (Kereluik et al., 2011) so that they are in a better position to undertake an ICT investment. Once instructors have integrated the three aspects (technology, pedagogy, and content), the study expects TVET teachers to present innovative instruction satisfying the needs of the 21st-century VET classroom (Loughran et al., 2012). Koehler et al. (2014) agree that TPACK emphasises how the connections between technology, pedagogy, and content knowledge interact for effective teaching and learning. Moreover, research has found that TPACK influences theory, research, and practice in teacher education and professional development.

3.2.1.1 Shortcomings of the TPACK framework in this study

Although research has accepted TPACK more than any other attempted framework by scholars, it also has weaknesses. For this study, TPACK does not explain how TVET teachers can acquire technological knowledge. It is neutral concerning the broader goals of education as it does not specify which content should be covered and through which teaching and learning methods (Mishra et al., 2011). In the same vein, while TPACK is rooted in a specific context,

a drawback lies in the insufficient comprehension of how contexts, the evolution of knowledge, and instructional methods interact (Mohamed, 2023). Despite numerous research studies on TPACK, much is still desired, particularly in understanding or examining how TPACK works in different disciplinary contexts. For example, TPACK lacks focus on a specific discipline if applied to the VET context because the needs of VET fields have varied outcomes but would need to be adjusted to the field of work and learning approach adopted in VET (Anderson et al., 2020; Arifin et al., 2020) and that becomes the basis for the evolution of TPACK in VET. Similarly, VET focuses more on practical learning and expertise than theoretical learning context. Sometimes, such contexts may pose challenges and barriers for TVET teachers to integrate technology into specific, more practical courses.

Furthermore, although it has surfaced as a theoretical framework in educational technology research, there is a need for more transparent and more precise definitions of the constructs before it can be established as a full-fledged theory (Rahimi et al., 2018). Researchers have underscored the framework's overlapping nature and expressed concerns about potential confusion among the constructs (Gong et al., 2022; Price, 2023;). Kimmons et al. (2020) added that one of the weaknesses of the TPACK model is its inability to generate novel insights, even though some argue for the possibility of enhancing the model. Therefore, the ongoing discourse about the vague and indistinct boundaries between these domains diverts attention from the original concept of TPACK as a comprehensive knowledge system.

Again, Aarkrog et al. (2018) revealed limited research on applying TPACK in VET. The quality of existing research on TPACK has also been patchy, and a need exists for better-designed studies and instruments. Hence, the study adopted the SDL theory to complement TPACK and expand on how TVET teachers acquire the TPACK and use such knowledge to integrate technology into teaching in the VET classroom.

3.2.2 Self-directed learning theory

According to Perera (2022), SDL gained popularity in 1970 by being formally recognised, conceptualised, and integrated into educational frameworks such as the Adult Learning Theory developed by Malcolm Knowles in 1968. Since then, several international journals on SDL have been published (Rabetino et al., 2018). According to Loeng (2020), researchers should view the SDL concept from multiple perspectives as it is multifaceted and challenging to understand from one definition. Previous research has noted the existence of terminological confusion regarding the SDL concept from the various definitions. One such terminology is

“self-regulation”, which is interchangeable with SDL (Linkous, 2021); however, this study focused on and used SDL because it allows the TVET teachers to have full control over what, how and when to learn. Although SDL has been present for years and studied extensively, it has never been at the forefront as a structured approach, emphasising its importance for adult learners and lifelong education (Rashid & Asghar, 2016).

Despite the terminological confusion, multifaceted issues and several definitions, the original definition of SDL is one that Knowles (1975, p. 18) noted, “as a process in which individuals take the initiative, with or without the help of others, in identifying learning needs, setting their goals, identifying human, and learning materials for learning, developing learning strategies and seeing that they achieve the learning outcomes”. Furthermore, researchers indicate that SDL is one of the methods by which TVET teachers can learn throughout their lives and careers to upskill and supplement knowledge from formal settings or training (LaTour & Noel, 2021). According to Coulardeau (2022), SDL focuses on adults (andragogy), where there is increased independence and use of experience and digital resources. Research has also noted that SDL is voluntary and takes place outside formal education, for example, in universities and VET programmes. Those involved in self-initiated learning design it explicitly to meet their learning needs and improve their knowledge and skills. In this study, TVET teachers’ needs were to learn how to integrate technology into teaching and be able to develop TPACK; hence, SDL would give them such an opportunity to acquire new knowledge while at the same time improving knowledge and skills learned in formal education.

Knowles (1975) highlighted five assumptions for adult learners: self-concept, learner experience, readiness to learn, orientation to learning, and motivation to learn. The five assumptions could potentially instigate TVET teachers to learn how to use and integrate technology into teaching in their classrooms because they become independent and develop SDL as they mature and progress in their careers. In addition, due to the diffusion of technology in education and some governments’ calls to use and integrate technology into teaching, TVET teachers are encouraged to teach with technology, forced to prepare and be ready to learn, and have to develop activities that simulate real-world work experiences for students. It is assumed in this study that some TVET teachers also take up SDL to contribute towards problem-solving and not just for subject-based teaching and learning as part of the orientation to learning. Lastly, TVET teachers are motivated by internal sources to learn, such as a desire to perform. Von Rueden et al. (2019) agree with Knowles’s five assumptions by highlighting three effective and relevant teaching principles: building on prior knowledge, learning in context, and

elaborating knowledge. Then, Olivier and Wittmann (2019) posit that acquiring skills through SDL creates a link between formal schooling and informal professional development. However, SDL only becomes possible when adequate resources, supportive and consistent leadership, and learning opportunities are available from external colleagues (Lemmetty & Collin, 2020).

To better explain the SDL concept, Kuril (2019) identified three dimensions of SDL: the sociological dimension deals with individual self-learning in social isolation embracing autonomy through web-based learning; the secondary, pedagogical dimension, which means that the individuals innovate their learning strategies which they are familiar with rather than the ones pre-determined by the curriculum; and the psychological dimension which is about personal characteristics, such as the abilities and skills of individuals involved in SDL. Therefore, with the help of the SDL theory, TVET teachers may be able to stand on their own, identify their skills gaps, set their goals, learn, and assess their learning.

There is a notable increase in research on the SDL concept (Loeng, 2020; Siswanto, 2024). For instance, Yasar and Atay (2023) stated that SDL encourages those involved in self-learning, such as self-directed learners, autonomous learners, or simply independent learners, with freedom, responsibility, and flexibility in learning. In this study, SDL also empowers the TVET teachers to develop the necessary competencies for lifelong learning. Further, Knowles (1975) posits that people involved in SDL learn better than those taught by someone else because they take ownership of their learning processes, actively identify their own learning needs, set goals, and engage in strategies that are tailored to their individual preferences and pace. Previous research has also shown that SDL can enhance the quality of education, which leads to achieving learning outcomes (Jeon & Park, 2021; Khalid et al., 2020). However, a different reason, apart from the benefits derived from SDL and found to have contributed to increased research on SDL, is the global societal and technological diffusion that requires specific skills and abilities (Joa et al., 2023). Therefore, this creates challenges as some TVET teachers are digital immigrants while others have little or no technological knowledge or skills. Nonetheless, finding themselves in the situation of having to teach with technology has put them in the space of learning how to do it.

Moreover, research has found various ways to conduct or undertake SDL. For example, Robinson and Persky (2020) state that SDL can be practised as either facilitated or self-paced. The difference between the two is that facilitated learning requires another person to provide

guidance and support, while self-paced learning is when an individual takes control of their learning by choosing resources. Fitria (2020) adds that educators can conduct facilitated learning through face-to-face, internet, or emails. In support, Shahba et al. (2022) state that educators also use approaches such as group discussion, audio-visual lecturers, flipped classrooms, case-based learning, and problem-solving learning to conduct SDL for facilitated learning, while strategies such as online courses, learning management system apps, digital books, research projects or YouTube videos are for self-paced learning. So, whichever approach is adopted depends on the available resources, motivation and capabilities of the individuals undertaking SDL.

In contrast, Lapidow and Walker (2022) indicate that not every individual can undertake SDL unless they possess SDL competencies. Particularly, Knowles (1975) listed general competencies of SDL, such as understanding the difference between facilitated and self-paced learning; an individual self-awareness of a self-directed being's ability to collaborate with peers and see them as resources for learning; abilities to identify skills gaps (learning needs); setting of achievable objectives; and the ability to self-evaluate and innovate corrective measures. Therefore, an individual should at least have some of those competencies, if not all, to undertake SDL. This study suggests that these are the same competencies that TVET teachers are expected to possess to self-learn. These competencies would empower TVET teachers to take control of their learning, ensuring they achieve their intended learning goals.

When TVET teachers are undertaking self-initiated learning, they are expected to be mindful of the SDL principles and characteristics to make it successful. These principles and characteristics comprise the SDL theory's components or elements. Considering these principles leads to TVET teachers' continuous professional development in their career journey. Figure 3.3 shows the principles individually below.



Figure 3.3: Key principles and characteristics of SDL theory

Source: Author's design

Figure 3.3 shows the fundamental principles and characteristics of the SDL theory, which the study assumes TVET teachers must consider before undertaking SDL. These basic principles and characteristics discussed below serve as guidelines for effective SDL.

This study focused on fundamental principles such as autonomy, self-motivation, prior experiences, and resource availability to effectively self-learn and integrate technology into teaching. SDL often contrasts with traditional teacher-centered approaches, where educators are the primary sources of knowledge and authority (Nasri, 2019). While conventional methods can be effective in specific contexts, SDL theory highlights the importance of empowering TVET teachers to participate actively in their education, promoting critical thinking, creativity, and a deeper understanding of the subject matter.

3.2.1.2 Autonomy

TVET teachers are encouraged to take ownership of their learning processes and decisions (Lepp et al., 2021). They can choose what and how they want to learn based on their interests, preferences, and personal goals. Vangrieken et al. (2020) identified autonomy in two ways:

personal and pedagogical autonomy. In this study, autonomy, as a core element of self-directed learning (SDL), provided valuable insights into how TVET teachers in Namibia acquired and developed TPACK, particularly given the limited formal training available in technology integration. Through interactions with the teachers, it became evident that they independently and proactively took the initiative to explore and apply digital technologies to enhance their TPACK development.

Autonomy allowed the study to illustrate how TVET teachers engaged in self-initiated learning. They reported actively seeking learning resources, experimenting with new technologies, and refining their teaching strategies without relying solely on structured professional development. This demonstrated their independence and self-determination in exploring and adopting technology for instructional purposes.

These findings support the idea that TPACK can develop organically through hands-on engagement with technology in everyday teaching practices (Kim & Kim, 2024). Thus, autonomy provided a lens for understanding how teachers independently select, implement, and refine technology-enhanced teaching methods, highlighting the role of self-directed learning in professional growth.

3.2.1.3 Self-motivation

SDL theory emphasises intrinsic motivation, the internal desire to learn for personal growth and development (Sawatsky et al., 2017). Thus, TVET teachers would undertake self-learning because they are motivated by various factors. This self-motivation element enables TVET teachers to find meaning and relevance in their learning, leading to a deeper engagement with the subject matter. Self-motivation helped me understand the lengths to which TVET teachers are willing to go to acquire the technological pedagogical content knowledge and develop TPACK. In this study, self-motivation helped identify and understand the underlying reasons behind teachers' learning behaviors. Their responses indicated a proactive approach to skill development, as they actively sought opportunities to enhance their technological competencies through online tutorials, peer collaboration, and hands-on experimentation with digital tools in their classrooms. This demonstrated an intrinsic desire to learn, characterised by continuous practice, exploration, and adaptation.

3.2.1.4 *Prior experiences*

Prior experiences play a significant role in SDL, shaping how individuals approach, navigate, and succeed in their educational journeys (Stol et al., 2023). These experiences encompass many factors, including previous learning encounters, personal interests, challenges faced, and strategies used. Understanding and leveraging these prior experiences can significantly enhance the effectiveness of SDL (Gerard et al., 2022; Paretti et al., 2020). In this study, teachers' prior experience enabled the understanding of their exposure to technology and whether such experiences has made a difference on how they are integrating technology into teaching and develop TPACK. Moreover, prior experiences helped the study analyse and understand if such experiences played a key role in shaping TVET teachers' ability to integrate digital technologies into their lessons. Prior experiences helped the study to understand whether teachers who could integrate technology was because of their experiences or not. Their ability to draw on both past successes and failures enabled them to refine their teaching strategies and improve their TPACK over time. Many teachers shared that before transitioning to education, they had worked in fields such as engineering, hospitality, or automotive technology. Additionally, their personal use of digital technologies, including smartphones, computers, social media, and online learning platforms, further informed their approach to integrating technology in the classroom. Therefore, their industry background and technological exposure served as essential prior experiences that influenced their teaching practices.

3.2.1.5 *Resources availability*

Resource availability in SDL offers a double-edged sword: an incredible opportunity for tailored, dynamic, and self-paced education, coupled with the responsibility of effective curation and use (Nusbaum, 2020). Therefore, those involved in SDL are responsible for navigating their learning path, making informed decisions, and actively seeking resources that align with their objectives (Zhu, 2021). The element of resources availability enabled the study to analyse and understand whether its availability or unavailability inhibits technology integration and TPACK development. The element of resource availability helped the study examine the gap between the inability to develop TPACK despite having access to resources and the assumption that a lack of resources is the primary barrier. Some of the resources highlighted were such as textbooks, online courses, articles, videos, podcasts, and interactive simulations. The availability of resources ensures that TVET teachers have the flexibility to tailor their learning experience to their preferences and pace, accommodating various learning

styles and preferences. Moreover, online platforms, libraries, educational websites, and digital repositories have transformed resource accessibility. However, the challenge lies in navigating this abundance of resources (Chen et al., 2019).

3.2.3 Justification for the adoption of the SDL theory

Although the SDL has always been part of adult education, research has not discovered a learning situation in which educators used the SDL in practice. The adoption of SDL theory aligns with contemporary educational goals of promoting lifelong learning, autonomy, critical thinking, and adaptability, making it a valuable framework for fostering meaningful, compelling learning experiences (Kharroubi & ElMediouni, 2024). The focus on self-directed learning (SDL) theory including its elements of motivation, autonomy, access to resources, and prior experiences served as a lens for examining how self-initiated learning activities support and constrain TVET teachers to integrate technology into teaching.

Numerous empirical studies have explored self-directed learning (SDL) in various contexts. For example, Louws et al. (2017) found that in the Netherlands, SDL is viewed as a typical and expected part of professional development, which contrasts with other settings where professional development tends to be more externally driven. Through regression analysis, Louws et al. (2017) discovered that the topics of self-directed learning for teachers varied based on their years of experience. Specifically, as teachers gained more experience, the time spent on learning subject-specific content decreased, while the time dedicated to mentoring novice teachers increased. In the same context, a study by Bonk et al. (2015) explored self-directed learning (SDL) within the framework of massive open online courses (MOOCs) emphasising an increasing interest on self-directed learning, reinforcing the idea that SDL is an essential skill for all adults. The study's findings show that adult educators utilise a variety of technologies and learning environments to meet their self-directed learning needs. Key motivational factors identified by participants included curiosity, interest, and an internal drive for self-improvement, particularly to acquire specific skills that would help them advance in their careers. Success and personal growth were attributed to the freedom to learn, access to abundant resources, and the ability to make choices, exercise control, and enjoy the learning process. To interpret the findings of this study, the researcher utilised the SDL theory as an analytical lens to explore how TVET teachers develop TPACK in a TVET context. This approach was driven by the literature review in Chapter Two, which highlighted a lack of research on TPACK development among TVET teachers in Namibia.

The study was interested in understanding how TVET teachers acquired technological pedagogical content knowledge and developed TPACK beyond formal training. Therefore, this study adopted Self-Directed Learning (SDL) theory, recognising the crucial impact of context in shaping TPACK. This approach allowed the researcher to consider various contextual factors, including access to technological infrastructure, institutional support, and school technology policies

3.2.4 Shortcomings of the SDL Theory

Despite the benefits of SDL, previous research has revealed that there are also limitations/challenges associated with SDL. Some challenges are behavioural barriers like readiness to self-learn, cognitive and mental barriers due to information overload, and lack of focus on learning and time management (Charokar & Dulloo, 2022). A study by Heo and Han (2022) found low teacher motivation as one of the weakness of SDL theory which can affect the overall quality of online learning. While motivation is influenced by teacher characteristics and can differ across different educational environments, it remains a crucial factor in SDL. In this study, I observed that SDL had the same weakness of affecting motivation because as I was comparing the empiricals, some TVET teachers revealed how they gave up their quest for self-initiated learning due to an overload of information which caused confusion and took much time to filter. This demonstrates that TVET teachers struggled to identify appropriate learning strategies, potentially resulting in knowledge gaps or ineffective learning. Farrand (2023) highlights that the abundance of resources and materials can lead to information overload, causing time constraints and pushing students toward passive learning strategies.

Rahman et al. (2022) identify a lack of self-motivation, limited support and resources, and insufficient skills as key challenges that hinder TVET teachers' self-directed learning. These challenges were also evident among the TVET teachers in this study as I observed that not all TVET teachers had access to necessary resources, such as technology and reliable internet connections, which are essential for self-learning how to integrate technology and develop TPACK. These teachers explained that their self-learning efforts were hindered by an unstable network and frequent connectivity disruptions. AlRadini et al. (2022) echoed similar concerns, noting that SDL presents challenges such as difficulty in selecting appropriate sources and materials, limited access to guidance or tutors, and inefficient use of time.

Moreover, research has criticised the SDL theory because it ignores social context, focuses on individuals as isolated learners, and stresses the social construction of knowledge and the social

context of learning (Loeng, 2020). In this study, my experience with the literature was twofold. Some TVET teachers engaged in self-initiated learning independently, at their own pace, and in their own space. This isolated approach overlooked the social context and limited opportunities for the social construction of knowledge among TVET teachers. In contrast, other TVET teachers fostered a collaborative environment where they actively engaged with peers, shared best practices, and learned from one another. This contradicts Loeng (2020), as these teachers embraced group learning within a structured social context, making the social construction of knowledge an integral part of their learning process. In addition, Morris (2018) clarified that research should redefine the individual dimension of SDL because it does not mean individuals who take responsibility for their learning make decisions in isolation.

3.3 Combination of the TPACK Framework and the SDL Theory

The study used all seven elements of TPACK to understand how TVET teachers integrate technology into teaching. The study used all the TPACK elements to analyse data about the TPACK that TVET teachers drew and developed to incorporate technology into teaching. The study used four elements (autonomy, self-motivation, prior experience, and resources availability) of SDL from its seven fundamental principles. The combination of these two theories stems from the fact that TPACK focuses on the knowledge domains (technology, pedagogy, and content knowledge) that TVET teachers must possess to integrate technology into their teaching.

The SDL theory aided me in this study as an analytical lens to explore how TVET teachers self-learn to navigate and negotiate their ways to integrate technology into teaching because the context in which they received training differs from the one in which teaching and learning occur. The theory was then employed to examine insights into how TVET teachers acquire knowledge and find ways to integrate technology. The theory also aided in learning how VET encourages andragogy, emphasising that the students are adults who learn differently from learners in primary and secondary education (El-Amin, 2020). Moreover, research has revealed that a competency-based curriculum supports SDL (Boyer et al., 2022); the VET curriculum is competency-based because it prepares trainees to work in an industry where they can practice the acquired competencies. SDL was also appropriate for this study because it allowed participating TVET teachers to deepen their reflection on different areas of knowledge, as illustrated by the TPACK framework.

In contrast, SDL focuses on how TVET teachers acquire the TPCK required for technology integration into teaching. Since TVET teachers need to possess knowledge of technological pedagogical content, it is crucial in this study to examine how instructors develop such knowledge by integrating technologies through self-learning. The study discussed all the knowledge domains that TVET teachers choose in the TPACK framework and then informed the combination of SDL theory and the TPACK framework to analyse how TVET teachers integrate technology into teaching. It was assumed in this study, that as TVET teachers take up self-learning, they acquire knowledge of technological pedagogical content, enabling them to integrate technology into their teaching. The study emphasised that TVET teachers' ability to self-learn depends on their possession of both the necessary skills and motivation.

Therefore, combining TPACK and SDL created a conceptual framework (See Figure 3.4 below) that would enhance the understanding of how TVET teachers can acquire the technological knowledge embedded in content and pedagogy for instructional purposes in the VET context. TVET teachers would also be better positioned to select the technological tools that suit the content and the instructional designs planned for lessons.

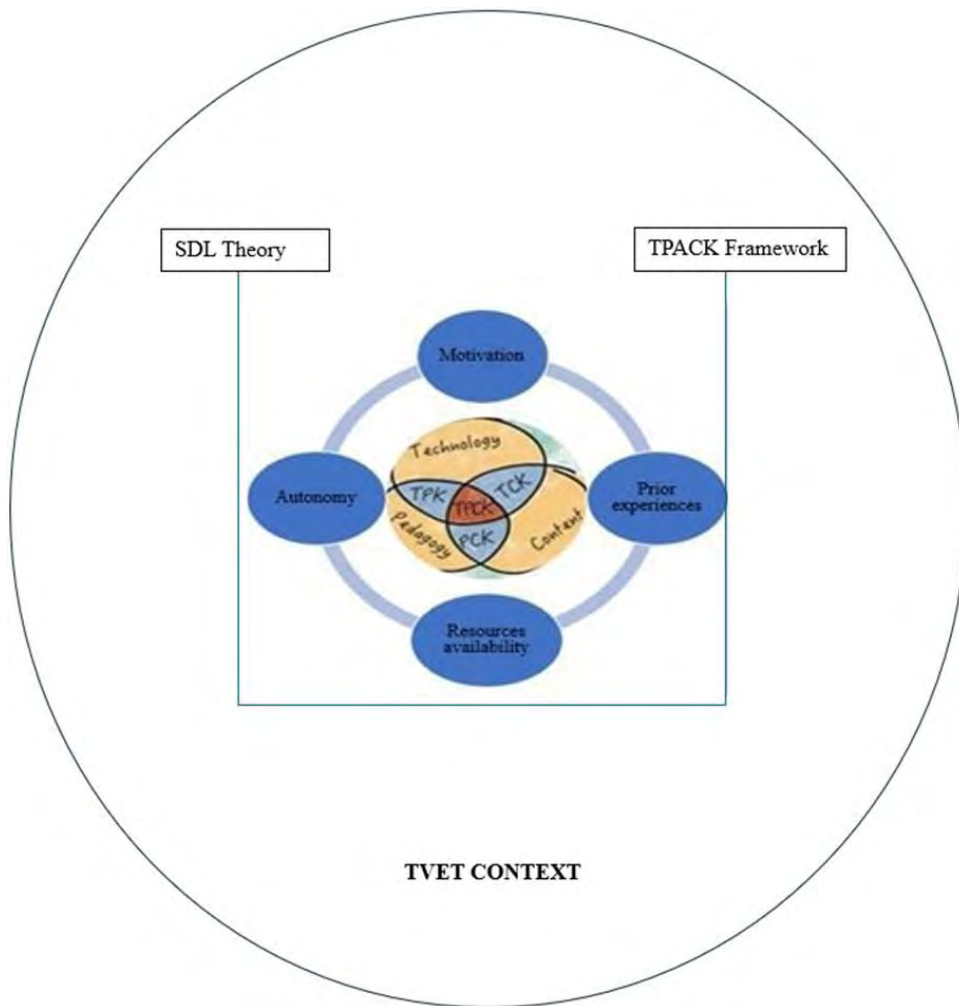


Figure 3.4: SDL and TPACK conceptual framework (Source: Author's design)

As shown in Figure 3.4 above, it was assumed in this study that TVET teachers can only integrate technology into teaching and learning if they devise strategies to balance the context they are teaching and the context in which they receive training. This approach may give them a better understanding of the technology they need to suit the content and the teaching strategy. In addition, motivation, autonomy (independence), previous experiences, and resource availability within the teaching context influence TVET teachers' SDL. Moreover, Figure 3.4 shows that the SDL theory and TPACK framework complement each other because they recognise self-learning and TPACK development as context-dependent. Further, all contextual matters were considered, such as resource availability, TVET teachers' prior experience, motivation, autonomy, and instructional design. It is, therefore, assumed that with SDL, TVET teachers can self-learn, construct, and realise the knowledge domains of TPACK.

3.4 Chapter Summary

The chapter analysed the TPACK and SDL frameworks that informed the study. The arguments were that although TPACK is a teaching theory, indicating that teachers need to possess the PCK to teach effectively and TPCK to integrate technology, it does not specify how teachers should acquire such knowledge and prepare. The SDL emphasises self-learning to learn how to incorporate technology in teaching, especially when a different context prevails during TVET teachers' training. Therefore, as TVET teachers take up self-learning, they acquire TPCK, enabling them to integrate technology into teaching. Thus, the study combined the TPACK framework and SDL theory to create a conceptual framework to enhance the understanding of how TVET teachers can acquire the technological knowledge to embed into content and pedagogy for instructional purposes in the VET context. The TPACK framework comprises seven elements adopted by the study to understand better how TVET teachers can acquire knowledge of technological pedagogical content for effective technology integration and TPACK development. The study also emphasised that TVET teachers should be conscious of the relationship between the TPACK elements and be able to create a match when planning their lessons. Although there are several vital principles of SDL, the study only adopted autonomy, self-motivation, prior experiences, and resource availability to effectively self-learn and integrate technology into teaching. TVET teachers can only self-learn when they are motivated to do so and as informed by their prior experiences and resource availability. SDL promotes autonomy by allowing TVET teachers to self-learn at their own pace, set goals, and evaluate their learning. Critics have raised objections against the SDL theory for neglecting social context, emphasising the theory's exclusive concentration on individuals as solitary learners. Instead, they emphasise the significance of the social construction of knowledge and the contextual aspects of learning.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

In the previous chapter, I presented the theoretical frameworks of TPACK and SDL that guided the study. Further, the study developed a new conceptual framework, a combination of the TPACK framework and SDL theory, that would enhance the understanding of how TVET teachers can acquire the technological knowledge embedded in content and pedagogy for instructional purposes in the VET context. I present the methods and the entire research process in this chapter.

The chapter begins by providing an overview of the research paradigm and highlights the paradigm adopted in the study. Second, the chapter discusses the research approach, which includes research designs such as explorative, descriptive, and explanatory as well as multiple cases. Third, the chapter gives an overview of the research site, research participants, and sampling methods applied in the study. Lastly, the chapter discusses the research process, data analysis, validity, reliability, trustworthiness, and ethical considerations in depth.

Pandey and Pandey (2021, p. 13) define research methodology as a “set of advanced decisions that make up the master plan specifying the methods and procedures for collecting and analysing the needed information”. When choosing a methodology for this study, I gave thought to the research questions, the kind of data to gather, and the theoretical lenses to apply to analyse the data. Thus, the study used an exploratory, investigative multi-case study method to draw on the qualitative approach located within the interpretive paradigm.

Table 4.1: A summary of the research methodology for this study

Research questions	• How do TVET teachers self-report and describe their TPCK in VET? • What TPCK sources do TVET teachers draw upon during SDL of integrating technology in the classroom? • How do SDL activities support and constrain TVET teachers to integrate technology into teaching? • What support do TVET teachers need to integrate technology into teaching and develop TPACK?
Paradigm	Interpretive

Approach	Qualitative
Method	Phase 1: Exploratory Phase 2: Reflective
Population	Teachers in VET institutions in Namibia Twenty-five TVET teachers: questionnaire Six TVET teachers: semi-structured interviews Six TVET teachers: non-participatory classroom observations Six TVET teachers: focus group discussions
Sampling techniques	Purposive sampling
Research tools and data collection	• TPACK questionnaires • Semi-structured interviews • Non-participatory classroom observation • Focus group discussions
Reliability and Validity	• Pilot testing of data collection instruments • Data triangulation • Exposure of participants to the same research instruments
Data analysis	• The survey data were analysed through counting, percentage calculation, and the creation of frequency tables. • Qualitative data were analysed thematically.
Ethical considerations	• I obtained approval for ethical considerations from the pertinent authorities. • Participants' rights, including informed consent, and voluntary participation were considered throughout the research. • The option to withdraw at any stage, confidentiality, anonymity, and privacy, were explained to participants.

4.2 Research Paradigm

A research paradigm is considered a researcher's worldview of the study (Khatri, 2020), particularly the point of view, mindset, ideology, or collective set of convictions that shape the understanding or analysis of research information (Steizinger, 2018). Other researchers, such as Kaushik et al. (2019), Manasseh et al. (2018), and Savin-Baden et al. (2023), explained the research paradigm as a mirror to the researcher's viewpoints about the existing and desired state of the world. It encompasses the theoretical convictions and fundamental concepts influencing a researcher's perception of the world and their manner of interpreting and engaging with it. So, in a nutshell, it is a lens through which the researcher understands the

research's methodological aspects to inform which data collection and analysis methods should be applied. The research paradigms are informed by whether the researcher conducts qualitative or quantitative research (Kivunja et al., 2017). Treagust et al. (2023) state that researchers should adopt various research paradigms, such as positivist, post-positivist, pragmatic paradigms, critical or transformative, and interpretive or constructivist.

4.2.1 The positivist paradigm

The positivist paradigm refers to a research perspective that is firmly rooted in the research methodology known as the scientific method of inquiry, relying on established knowledge and principles (Mohajan, 2020). According to Kankam (2019) and Park et al. (2020), the positivist paradigm has been used more in the natural sciences, where empirical observations serve as the foundation for developing theories and models that have broad applicability. In addition, positivism ignores context and strives to establish general principles without consideration for the specific environment or circumstances (Kankam, 2019).

4.2.2 The post-positivist paradigm

The post-positivist research paradigm is a philosophy that recognises the existence of an objective reality through empirical methods but also acknowledges the challenges of achieving complete objectivity and certainty (Maksimovic & Evtimov, 2023). Further, the introduction of post-positivism resulted from a reaction to the limitation of positivism and to strike a balance between positivism and interpretivism. Research saw early post-positivism in social science in Max Weber's work during the late 19th and early 20th centuries (Hall & Hall, 2020). Weber emphasised the importance of understanding social phenomena from the perspective of those involved rather than from an external viewpoint.

4.2.3 A critical or transformative paradigm

A critical or transformative paradigm in research is a philosophical and methodological approach that emphasises examining and transforming societal structures, power dynamics, and inequalities (Bosio, 2022). The transformative paradigm operates on the belief that research should focus on both understanding the world and transforming it (Hurtado, 2022). De Oliveira (2023) and Conger et al (2017) states that the transformative paradigm resulted from the limitations of traditional research methodologies specifically the inability to bring about major social change. However, the transformative research paradigm is grounded in

critical theory, which asserts that society is marked by structural inequalities that lead to social injustice (Carducci & Pasque, 2025) and seeks to challenge and address these inequalities through research. Despite its benefits and importance, researchers employing transformative paradigms have frequently faced challenges in identifying methods that align with their goals during the design, implementation, and evaluation stages (Hölscher et al., 2021; Simuja & Shikesho, 2024). In addition, the absence of a common understanding of what defines transformative research has made it challenging to compare different studies. Furthermore, its value-driven and goal-oriented nature can complicate the creation of objective measures or impact assessments (Gebhardt, 2020). In addition, transformative research often demands significant participant involvement (Thambinathan & Kinsella, 2021), which can be difficult to secure. Accordingly, Garnett et al. (2019) note that research has linked the transformative perspective to representing diverse interests, voices, and viewpoints.

4.2.4 The pragmatic paradigm

The pragmatic paradigm in research is a philosophical and methodological approach that emphasises practicality, problem solving, and the application of research findings to real-world situations (Kaushik & Walsh, 2019). Pragmatists emphasise discovering practical solutions, making this paradigm a foundational approach in healthcare investigations, educational studies, and sociological and psychological research (Kaushik & Walsh, 2019; Shannon-Baker, 2016). It views research questions as more important than methods of obtaining data to answer them.

4.2.5 The interpretivist paradigm

The interpretivist tries to comprehend the personal realm of human perception and encounters, elevating it to grasp the observed individual's perspective instead of their own (Koopman et al., 2017). According to Kumatongo et al. (2021), an interpretivist paradigm focuses on understanding a particular context, such as the instructors teaching vocational training schools, to pave the way for data interpretation. Therefore, this qualitative study adopted an interpretivism paradigm, which allowed me to understand the meanings, thoughts, and views of the TVET teachers on integrating technology into their teaching. This study fits in well with the interpretivist paradigm because it used multiple methods of collecting data (Alharahsheh & Pius, 2020) to derive and understand meanings from TVET teachers on how they self-initiated learning to integrate technology into their teaching. Specifically, I assumed the participants would share their views, definitions, and interpretations of TPACK development.

Further, the study under the interpretivism paradigm also used social constructions such as language, shared meanings, and instruments to access reality (Antwi & Hamza, 2015). Kivunja et al. (2017) support social construction, stating that researchers construct reality through the interpretive paradigm, which is why it is called a constructivist paradigm. Further, I describe the four elements, namely, ontology, epistemology, naturalist methodology, and axiology that make up the study's paradigm below (Kivunja et al., 2017):

4.2.5.1 Ontology

Ontology in philosophy examines how we perceive meaning and authenticity, which is the core nature of this study (Maslin, 2020). It explores into existence, reality, and entity categories while evaluating a researcher's underlying beliefs about fundamental aspects of existence. In this study, I believed in exploring the multiple realities of how TVET teachers try to negotiate their ways to integrate technology, finding the interpretations of their realities through the interactions among the TVET teachers. Moreover, it was essential to perceive TVET teachers as active participants with a purpose, having knowledge of thoughtful technology use and skills to generate experiences and attitudes towards technology in their professional settings. The study assumed that TVET teachers could contemplate and review their practices and decisions. To thoroughly understand the participants, I considered their personal and shared contexts, conditions, and life experiences alongside other teachers and learners.

4.2.5.2 Epistemology

Epistemology studies how we gain understanding and discover truths about reality. Willig (2019) defines it as identifying what constitutes knowledge. This field examines the core elements of knowledge, including its nature, types, acquisition methods, and communication. It focuses on understanding human cognition and supports researchers in deepening their understanding within their field (Guercio, 2020). Through subjectivist epistemology, the study derived significance from the data by processing it through cognitive mechanisms (Cuthbertson et al., 2020) influenced by engagements with TVET teachers, which socially construct knowledge based on TVET teachers' first-hand encounters with real-life situations explored within their natural settings. I engaged the TVET teachers through interviews, focus group discussions and classroom observation.

4.2.5.3 Methodology

Regarding the methodology, the study solicited access to an in-depth understanding of the instructors' TPACK through various data-gathering techniques. These were questionnaires, interviews, observations, and focus group discussions, as per the interpretive paradigm traditions (Cohen et al., 2018), and these led to the validation of the findings through data triangulation. The study used these data-gathering techniques because interpretivist studies focus on meanings and use multiple data collection methods, making way for trading off biases generated from one method over another.

4.2.5.4 Axiology

Axiology relates to the moral concerns that require attention during the formulation of a research proposal and throughout the research process (Kivunja et al., 2017). It contemplates the philosophical method of determining valuable or morally correct choices. Kivunja et al. (2017) advise that interpretivism is required to observe balanced axiology, which this study reflects as per the researcher's value when presenting the study results. Although interpretivism allows an in-depth discussion of the phenomena, leading to a high level of validity, the researcher cannot generalise the data to other contexts due to personal views and values in the studied context.

4.3 Research Approach

Harrison et al. (2017) define the research approach as “an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (p. 14). This study adopted a qualitative research approach. Ormston et al. (2014) assert that qualitative research aims to uncover the meaning behind characteristics or activities involving individuals. It is about the descriptions of the experiences of those involved. Qualitative research methodologies foster a deeper understanding of each participant's thoughts and convictions, necessitating more extensive data gathering for everyone involved (Bresler, 2021). Specifically, the study adopted the qualitative design for three reasons: I aimed to understand people's experiences and was the first point of contact for data collection (administering questionnaires, interviewing, focus group discussion and observation) as it allowed me to analyse the data inductively so that concepts and themes could be generated (Forman & Damschroder, 2007). Only in qualitative research can a researcher generate detailed descriptions after having used multiple sources of data collection (Moser & Korstjens, 2018),

as is the case in this study. This study's qualitative approach enabled me to explore multiple instances of how individual TVET teachers integrate technology into teaching.

4.3.1 Multiple cases

This study employed a multiple-case study design to explore how TVET teachers integrate technology into their teaching within the real-life context of vocational centres. According to Zhang and Creswell (2013, p. 54), “a multiple-case design explores real-life multiple bounded systems through detailed, in-depth data collection involving multiple sources of information”. The study selected a multiple-case study because it allowed me to explore the research questions and theoretical stance in depth to obtain holistic views and understand the differences and similarities between the studied cases (Koltovskaia, 2020). Furthermore, I analysed the behaviours of multiple cases (the participants) by examining their responses and perspectives on TPACK. The study adopted a multiple-case study because using a single case study is only suited when an entity or a phenomenon is in its real-life context (Cleland et al., 2021; Halkias & Neubert, 2020;). In addition, a multiple case is appropriate mostly when the phenomenon of interest occurs in different settings or under varying conditions as a multiple-case study can reveal how different contexts influence the phenomenon (Rashid et al., 2019). For this study, a multiple-case study design led to more analytical benefits by gaining deep insight into individual participants as a case, allowing independent conclusions emanating from each case and resulting in unified commonalities, than studies focused on a single case (Li et al., 2018; Urbinati et al., 2019). The literature indicates that researchers adopt few single case studies in education because of the uniqueness of the case or conditions surrounding the case (Baxter & Jack, 2008; Flyvbjerg, 2004; Stake, 1995).

Moreover, multiple cases in this study permitted each case to bring its perspectives from which commonalities that bound the cases together emanated (Urbinati et al., 2020). It is evident that within this multiple-case study, each of the six participants represented a unique case and description of a VET teacher's TPACK. Furthermore, the multiple-case design enhanced the study's rigor by providing opportunities for both literal and theoretical replication, strengthening the validity and generalizability of the findings (Monteiro et al., 2016). Similarly the diversity of six cases allowed for a richer understanding of the phenomenon of integrating technologies in TVET in Namibia. Furthermore, the selection of cases from different vocational centers within the Namibian TVET sector enabled exploration of how contextual factors influence technology integration practices. The cases included both experienced and

novice teachers provided insights into the developmental trajectory of technology integration skills. Finally, the cases form a range of teaching specializations within the TVET sector, ensuring the reliability of findings across different vocational disciplines (Gillham, 2000; Monteiro et al., 2016). Further, in exploring each case, this research aimed to understand how each case uses and integrates technology into their teaching and how SDL enables them to develop their TPCK within VET.

4.4 Research Design

Research design is the comprehensive strategy for linking theoretical issues with practical and attainable empirical research (Asenahabi, 2019). In other words, the research design establishes the process for obtaining necessary data and the techniques for gathering and examining that data and outlines how these elements will address the research query. There are three forms of research design: exploratory, descriptive, and explanatory (Cevikbas et al., 2023). According to Clark et al. (2021), exploratory research is a methodology used when researchers want to gain initial insights, generate ideas, or develop hypotheses about a subject before conducting more in-depth investigations. A descriptive research design is a methodology that systematically describes and documents the characteristics, behaviours, and attributes of a particular population, group, or phenomenon without manipulating or altering them (Möttus et al., 2020). However, an explanatory research design is a research methodology that seeks to explain and clarify causal relationships and underlying mechanisms between variables or factors (Asenahabi, 2019; Pandey & Pandey, 2021).

This study adopted the exploratory research design because this research topic is new, and there is no existing knowledge about it in Namibia. Further, it allowed me to gain in-depth insight into each case of technology integration in VET classrooms through the various data collection methods.

4.5 Research Site

The research sites were all VET centres within the country. Due to the diversity of teaching contexts and the varying levels of technology integration across different VET centers, it was essential to sample teachers from multiple centers to ensure a comprehensive representation of the phenomenon. There are currently seven public VET centres and seven privately owned VET centres in the country (see Figure 4.1 below).

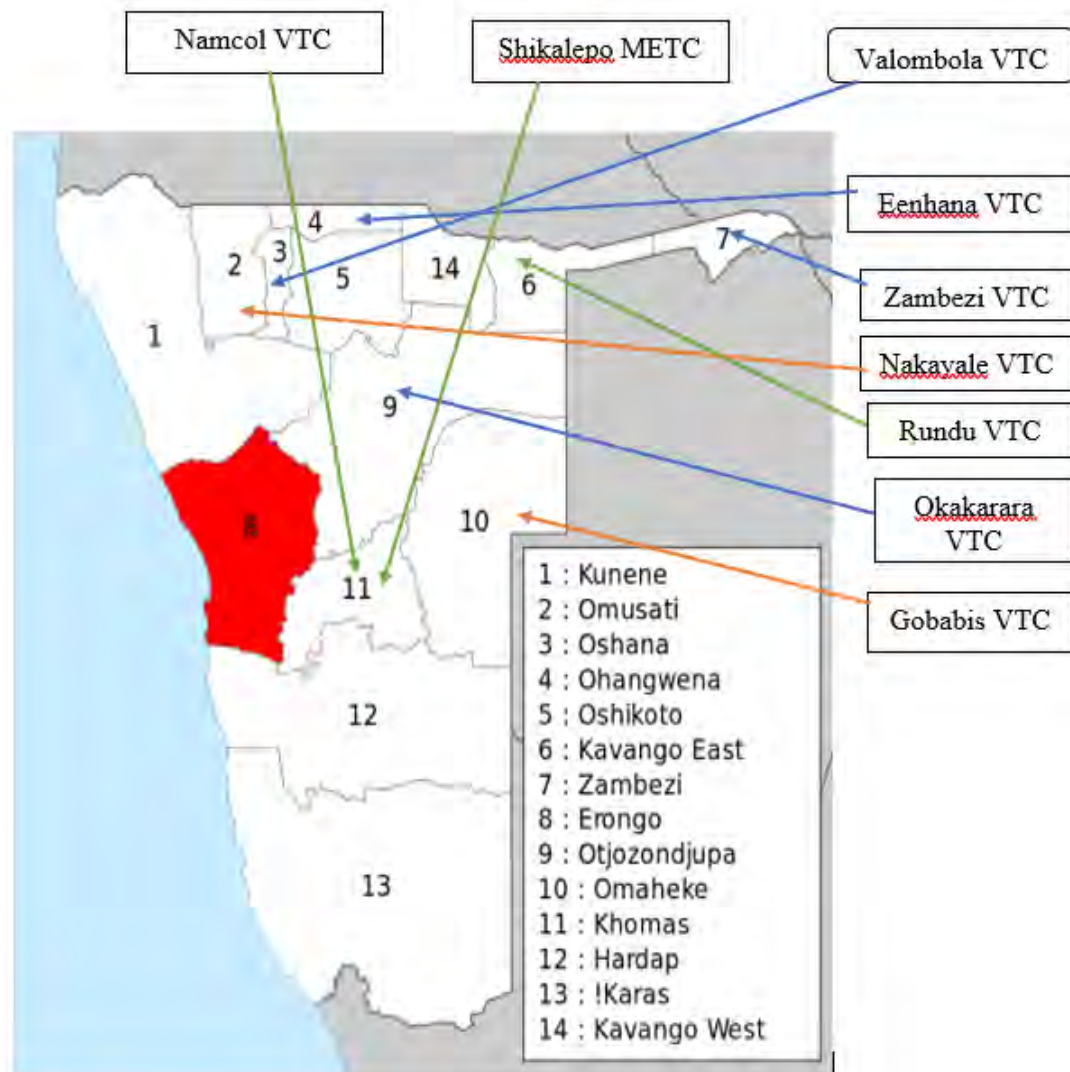


Figure 4.1: The VET centres

Figure 4.1 shows the various VET centres found within the different regions in Namibia which are managed by the Namibia Training Authority (NTA).

4.6 Selection of Participants

The participants for this study were TVET teachers teaching at various VET centers throughout in Namibia. The participants were identified through the annual retreat meeting for VET teachers in 2023. All attendees of this meeting totalling 25 number of teachers were invited to participate in the study by completing a questionnaire. Following the questionnaire phase, six participants from the initial 25 expressed their willingness to participate further in the study,

involving semi-structured interviews, non-participatory lesson observations, and focus group discussions.

4.7 Sampling

Sampling in research refers to selecting a subset of individuals, items, or elements from a larger population to gather data and make inferences about the entire population (Mweshi, 2020). Etikan et al. (2019) posit that since studying the population is often impractical or impossible due to constraints such as time, cost, and resources, researchers use sampling techniques to obtain a representative sample that can provide insights into the characteristics, behaviours, or attributes of the larger population.

This study used a criterion sampling technique to select 25 TVET teachers as participants who were intended to fill in the questionnaires. Criterion sampling allowed all participants meeting the same criteria to be reviewed and studied (Hasson et al., 2000). Further, criterion sampling enabled me to understand TVET teachers' rich information on integrating technology and developing TPACK. The sampling technique allowed me to select participants who met specific criteria. Therefore, the 25 TVET teachers were selected based on the following criteria: must possess more than three years of teaching experience in VET, must have access to technology device (s), must be teaching level one up to three of vocation training disciplines, and should self-integrate technologies in teaching. I added a section to the questionnaire for the 25 TVET teachers to indicate if they were willing to take part in semi-structured interviews, non-participatory lesson observations, and focus group discussions. As a result, six of the 25 teachers who completed the questionnaire showed interest and became the main focus cases for this study.

4.8 The Research Process

Once the research problem or area of interest has been identified, the researcher must determine the appropriate method(s) to address the phenomenon. According to Rashid et al. (2019), the research process is a systematic and organised approach that scholars, researchers, and academics follow to investigate a specific topic, generate new knowledge or answer research questions. The process typically consists of several interconnected stages or phases, each designed to contribute to the overall understanding and advancement of a particular field of study.

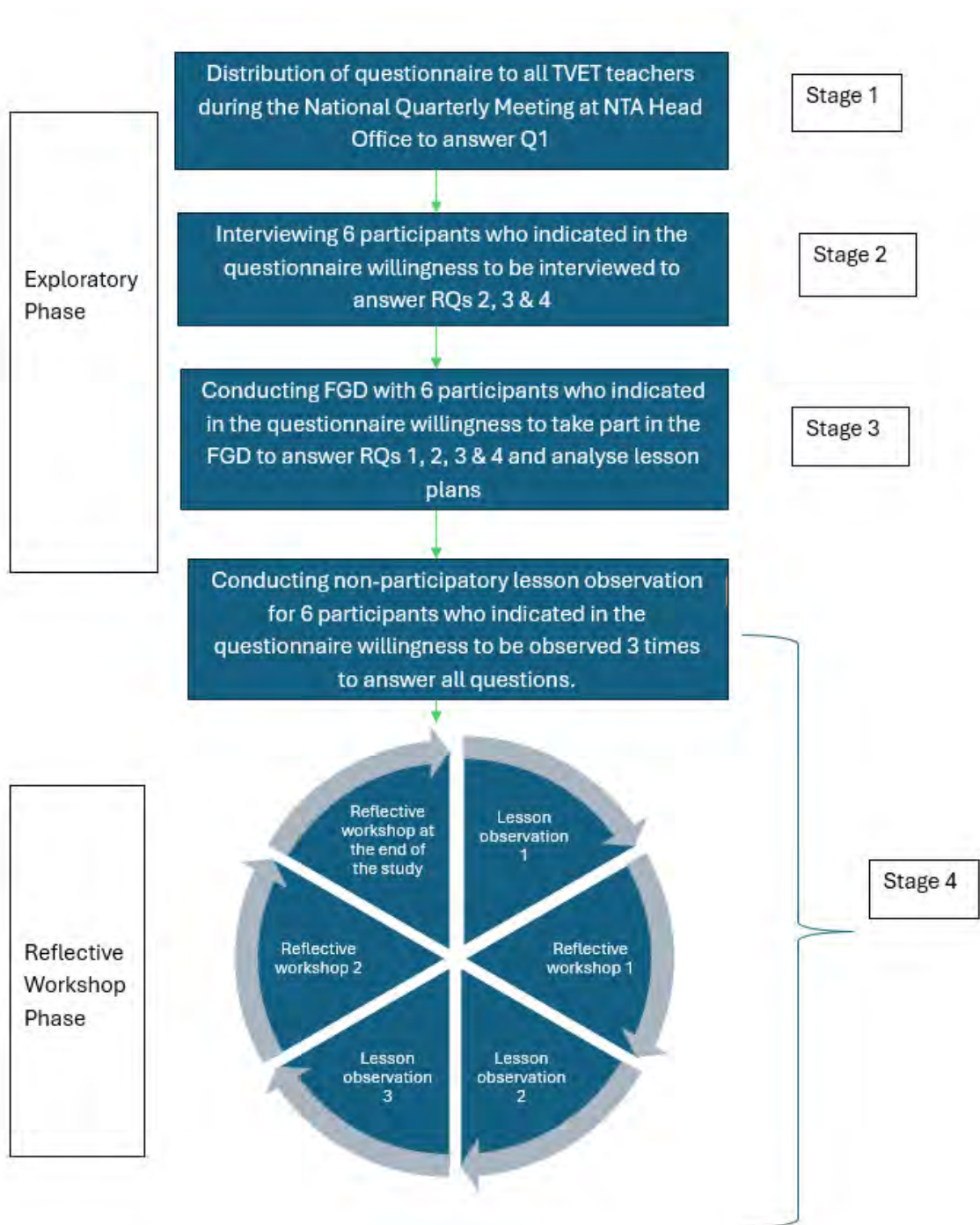


Figure 4.2: The research process

Figure 4.2 shows that I undertook the study in two phases: phase one was exploratory, which comprised the data-gathering procedures and was conducted in three stages, while phase two, the fourth and last stage, was a reflective phase where I observed participants' lessons and then held a reflective workshop to member check and verify the findings of the study.

4.8.1 Exploratory phase

I conducted this phase in three stages. I explored the TVET teachers' TPACK, technology use, and overall understanding of TPACK to establish how they integrated technology into teaching and eventually developed TPACK to provide answers to the research questions.

So, I could only gather such data through questionnaires, semi-structured interviews, focus group discussions, and lesson observation to gain an in-depth understanding of differing perspectives of the multiple cases.

4.8.1.1 Questionnaire

According to Schurink (2009), a questionnaire is a data collection instrument consisting of a series of questions for the participants to answer. Questionnaires were used because they allow the capture of objective data, are easy to prepare and administer, and enable the researcher to collect data from a large group of participants (Nayak & Narayan, 2019) (See Appendix D). Since VET centres are scattered nationwide, I took advantage of the TVET teachers' national quarterly meeting at Windhoek's NTA head office. Therefore, I distributed hard copies of the questionnaires to the 20 TVET teachers who attended the national quarterly meeting face-to-face and emailed the soft copies to five TVET teachers who could not attend the meeting. The participants completed all 20 questionnaires. However, the five TVET teachers who did not make it to the meeting could not return the soft copies emailed to them. The questionnaires yielded incomplete responses from some participants due to ambiguities in certain questions. Since I was absent when the TVET teachers completed the questionnaires, clarifications could not be made, and participants opted not to respond to the questions and responded based on their understanding (Stedman et al., 2019) (See Appendix E). In addition, the questionnaire placed greater emphasis on individual knowledges rather than collected knowledges. To address this, I employed a semi-structured interview, non-participatory observation and FGD to ensure cross-verification of the findings. By utilising multiple research instruments, I aimed to achieve data triangulation and strengthen the validity of the results. At the end of the questionnaire, participants had the opportunity to express their interest in participating in semi-structured interviews, sharing circle discussions, and lesson observations. Out of the 20 completed questionnaires, six participants indicated their willingness to take part in semi-structured interviews, focus group discussions, and lesson observations for further data collection.

4.8.1.2 *Semi-structured interviews*

I obtained permission to interview six TVET teachers to uncover their first-hand experiences, knowledge, and expert opinions regarding technology integration. According to Heath et al. (2018), interviews are research approaches in which the researcher and the participants have personal interactions, enabling detailed data gathering. This study used semi-structured interviews because they allowed me to clarify details and ask follow-up questions to participants, enhancing discussions between the participants and me (Johnson et al., 2020; Roberts, 2020). Each interview session lasted about 30–60 minutes because some participants were more vocal and could explain in detail. All interviews were audio recorded. In this study, I conducted face-to-face semi-structured interviews, as all six TVET teachers were from VET institutions. In addition, Prosek and Gibson (2021, p. 12) stated that interviews “offer a high return rate, fewer incomplete answers, and controlled answering order”. I collected detailed and context-specific data on TVET teachers’ technology integration. However, two participants could not explicitly state in detail, and when asked follow-up questions, they only explained in a few sentences. Another concern was the time taken during the interview. Some participants, such as Iyambo and Ndangi, took longer to explain their points, which limited others’ opportunities to speak. To address this, I allocated equal time to each participant for every question to ensure fair and equitable participation. My role was to ensure that each participant fully engaged in the interview process while also maintaining control over the entire interview as the interviewer.

4.8.1.3 *Focus group discussions*

Although I interviewed all six TVET teachers, their responses were prone to researcher and participant subjectivity (Lykes et al., 2007) as there were likely some power dynamics between the selected TVET teachers and me, as well as peers and work colleagues (See Appendix F). These power dynamics meant that my role may have created a perception of authority, potentially influencing how teachers engaged with the study. Teachers might feel pressured to provide responses they believe align with my expectations. Moreover, power dynamics may have emerged from variations in experience, qualifications, or roles, with senior teachers often assuming leadership positions that influence group discussions and decisions. This dynamic could affect the authenticity of their participation. Thus, I conducted a focus group discussion (FGD) by taking up the role of a facilitator to mediate the talks between the participants as they offered their experiences on self-learning and integration of technology into teaching and

developing TPACK. A FGD is considered cost-effective and a promising alternative to uncovering participants' perceptions and values on SDL (Vedi & Dulloo, 2021). I conducted two FGDs, which lasted roughly one hour and a half each, so the six participants had adequate time to exhaust their discussion and avoid fatigue and boredom. The first FGD occurred after conducting classroom observations for the first three TVET teachers and the second after the researcher had observed teaching by the last three TVET teachers. The FGD was done after conducting the classroom observations to clarify certain interactions, teaching methods, or behaviours noticed during the observation. To confirm the findings and gain deeper insights that might not be apparent from a single observation, the researcher asked participants to explain the thinking behind specific acts. As per the research process, I planned to observe one lesson for each participant. However, most participants requested me to observe at least two lessons as they felt the study was more aligned with improving their teaching and technology integration.

All six participants took part in the two FGDs. During the first FGD, all participants interacted well and built upon each other's responses while not all participants fully participated in the discussions during the second FGD. However, since the FGD was conducted via a group WhatsApp call because of the challenge of bringing all participants together, it became difficult for me to control the participants. This is because there were distractions going on during the whatsapp call which was evident from the multiple beeping sounds of notifications on participants' mobiles. To address the issue, I stressed to the participants the value of their full and active participation on the discussion to derive maximum benefits from the study findings. Therefore, as the facilitator, I had to guide the conversation by promoting open and balanced participation while ensuring the discussion stayed on track.

4.8.1.4 Non-participatory observation

According to Smit and Onwuegbuzie (2018), observation involves collecting data through seeing and listening. This study used a non-participatory observation method because I would have direct access to participants (Gray et al., 2020) and, by observing their behaviour, it was possible to gain a deeper and more comprehensive understanding of how TVET teachers integrated technology into their teaching and how they developed TPACK within the VET context (See Appendix G). I conducted one lesson observation for the six TVET teachers for two months. During lesson observation, I also analysed the TVET teachers' lesson plans and how they integrated technologies into their classrooms. Moreover, I analysed two lesson plans

from previous lessons that I had not observed during each observation. I concentrated on observation and was wholly detached from influencing the behaviour of both students and the instructor during the observation. Although the intention was to observe one lesson as per the research process, three participants requested me to observe more than the one lesson as they felt the study was more aligned with improving their teaching and technology integration.

Similarly, I noted the hidden nature of non-participatory observation, as I could capture the authentic teacher-student interactions and natural use of technology without influence from my presence. Moreover, it enabled me to capture spontaneous and unscripted events, which could be overlooked during interviews, enriching the dataset with subtle yet significant occurrences. It was also supported in this study by developing a comprehensive analysis of TVET teachers by conducting repeated, consistent observations across multiple classes, which revealed patterns and trends in how technology was integrated into teaching across various cases. However, as an insider I was affected by how the participants were engaging in the classroom, I maintained an outsider perspective to avoid influencing the classroom dynamics. My role was solely to observe without actively participating by asking questions, sharing my views, or making comments. To address this issue, I compared the participants' observed behaviors with their explanations from semi-structured interviews and focus group discussions to gain insight into their intentions and emotions.

4.8.2 *Reflective workshop*

I conducted reflective workshops not as part of data collection but as a way to engage participants in validating the findings. During the reflective workshop, I engaged selected TVET teachers to validate the accuracy and interpretation of collected data. The participants were allowed to member check if the presented data accurately represented their experiences, knowledge and perspectives. In addition, I received TVET teachers' input on any potential gaps or discrepancies found in the findings, and interpretation was refined. The reflections from the workshop served as valuable supplementary data for the study, providing further context and support for the research findings.

There was open communication and understanding among the participants. However, two participants felt uncomfortable, especially when sharing personal experiences and verifying the content of the semi-structured and non-participatory classroom observations. I had to reiterate to the two participants that their personal experiences and any information shared would be

kept confidential and protected using pseudonyms as already stressed at the beginning of the research process.

The reflective workshop played a crucial role in validating the research findings by providing a platform for participant feedback and collaboration. The workshop was structured around discussions where participants were presented with key findings and encouraged to share their perspectives. The reflections during the discussions allowed for the identification of potential biases and misinterpretations and strengthening the credibility of the research. The impact of the workshop was evident in the refined interpretations and the richer understanding of the data. Furthermore, the collaborative nature of the workshop enabled a sense of ownership among the participants, increasing the findings being accepted and implemented within the TVET context. Furthermore the insights gathered during the workshop provided valuable supplementary data, enhancing the overall quality and depth of the research.

Table 4.2 shows the research questions and how data was generated and analysed from the objectives:

Table 4.2: Research questions

RESEARCH QUESTIONS	DESCRIPTION	DATA GENERATION TOOL	ANALYTICAL FRAMEWORK
How do TVET teachers self-report and describe their TPACK in VET?	TPACK, as a dynamic form of knowledge, is complex and shaped by specific contexts (Kohler & Mishra, 2009). Different environments cause TPACK to exhibit unique, flexible, and context-specific qualities that vary for each teacher in different situations (Hood, 2018). The self-reported TPACK insights from TVET teachers in VET provide a deeper understanding of how their TPACK develops within the distinctive context of VET.	Questionnaire Semi-structured interviews Non-participatory classroom observation Focus group discussion	TPACK
What TPACK sources do TVET teachers draw upon during	In pursuing self-initiated learning for technology integration, TVET teachers navigate various TPACK	Questionnaire	TPACK and SDL

self-initiated learning of integrating technology into the classroom?	sources to enhance their teaching methods. TVET teachers engage in a dynamic process, continuously drawing from multiple resources, including formal professional development, online exploration, and hands-on classroom experiences, to adapt and evolve within the ever-changing landscape of education in the digital age.	Semi-structured interviews Non-participatory classroom observation Focus group discussion	
How do self-initiated learning activities support and constrain TVET teachers to integrate technology into teaching?	Self-initiated learning activities both support and challenge TVET teachers in their efforts to integrate technology into their teaching practices. On the supportive side, these activities provide teachers with autonomy, enabling them to explore various TPACK resources. However, the independence they offer can also be limiting, as teachers may experience information overload or struggle to identify the most relevant and effective technologies for their specific contexts.	Questionnaire Semi-structured interviews Non-participatory classroom observation Focus group discussion	TPACK and SDL
What support do TVET teachers need to integrate technology into teaching and develop TPACK?	Comprehensive support to integrate technology into teaching and develop TPACK effectively is pertinent for TVET teachers. Practical guidance on aligning technology with specific content and pedagogical approaches within their subject areas is also crucial.	Semi-structured interviews Focus group discussion	TPACK

4.9 Positionality and Reflexivity

In the orbit of research, the researcher should recognise and address potential personal biases that could impact the outcomes. In addition, it is essential to acknowledge the existence of power dynamics between the researcher and the participants, as noted by Avraamidou (2020),

Olmos-Vega et al. (2023), and Wallerstein et al. (2019). The researcher must clearly define their role, with Chan (2023) emphasising the primary roles of a researcher and a learner.

Considering these factors, I acknowledged my role as a part-time VET teacher for the past decade. This insider position rendered me a participant in the study focused on integrating technology among VET teachers. Understanding the potential influence of my role as a fellow instructor or colleague among the participating TVET teachers, I remained mindful of how this dynamic might impact our relationship throughout the study. To address potential power imbalances, I consciously positioned myself primarily as a learner, aligning with the approach recommended by Lykes et al. (2007) and Miceli et al. (2020). I needed to avoid misusing my role as a part-time VET teacher to exert undue influence on the participants. Instead, I conducted the research with integrity, adhering to established principles.

Further, there were biases in how I prepared the questions in the questionnaire and semi-structured interviews (Chenail, 2011), which were managed by having the data collection tools reviewed by experts from the community of practice and piloted with VET experts for any subjectivity. Moreover, Gasper et al. (2019) noted that there may exist cultural differences the researcher must consider when conducting research, such as the diverse ethnic and tribal groups, and that the cases may not necessarily be Oshiwambo as I was; hence, I respected each case's culture, values, and norms to avoid being bias and acknowledged prior assumptions. I also acknowledged and respected both the participants' age, colour, gender, and marital status, as well as my age, colour, gender, and marital status, ensuring that these factors did not influence how the study was conducted (Holmes, 2020). I acknowledge the presence of subjectivities throughout the research process and took deliberate steps to minimize their impact. To counteract the influence of my background, I implemented precautions at various stages of the study. During data analysis, I consciously set aside personal experiences and expectations to ensure that interpretations were based on evidence rather than preconceived notions.

Furthermore, in research the researcher should recognise and address potential personal biases of their insider or outside position that could impact the outcomes (Merriam, 2018). So, I made it clear from the beginning that I acknowledged my role as a part-time VET teacher for the past some years. This insider position made me a participant in the study focused on integrating technology among VET teachers. Understanding the potential influence of my role as a fellow instructor or colleague among the participating TVET teachers, I remained mindful of how this

dynamic might impact our relationship throughout the study. To address this imbalance, I consciously positioned myself as a learner. I needed to avoid misusing my role as a part-time VET teacher to exert undue influence on the participants. Instead, I conducted the research with integrity, adhering to established ethical principles from participating VET institutions and Rhodes university.

Further, I recognised a minimal influence on participants and addressed this by fostering a neutral and open research environment, encouraging them to share their experiences without feeling pressured to align with my expectations. Although my insider position offered valuable insights, I actively maintained a critical stance by questioning assumptions, seeking diverse perspectives, and balancing my insider knowledge with an outsider's analytical approach.

Simultaneously, my role as a researcher demanded an objective, outsider's lens ensuring the study's reliability and validity. Navigating the dual roles (insider and outside) required careful ethical consideration, as highlighted by Hayfield and Huxley(2015). This balance was maintained through transparent communication with participants and adherence to research ethics. Both my insider and outsider statuses were handled ethically, contributing to the study's validity and trustworthiness.

4.10 Data Analysis

Data analysis is inspecting, cleansing, transforming, and interpreting data to discover meaningful insights, draw conclusions, and support decision-making (Hamdam et al., 2022). Further, Sivarajah et al. (2017) posit that it involves various techniques and methodologies to explore and understand a dataset's patterns, relationships, and trends. Data analysis transforms raw data into actionable insights, enabling organisations and individuals to make informed choices and solve complex problems. The specific techniques and tools used can vary widely depending on the domain and the complexity of the data (Barber & Krarti, 2022). In this study, I used an inductive approach (thematic analysis) to analyse the data following the analysis process by Braun and Clarke (2021).

4.10.1 Data analysis in the exploratory phase

In this study, I analysed data collected from the questionnaire's closed-ended questions statistically using percentages and frequencies and presented in tables and charts (Kuckartz & Rädiker, 2021) to examine how instructors integrate technology in teaching and develop

TPACK. Furthermore, analysing the qualitative data collected from semi-structured interviews, focus group discussions, and lesson observations, I used an inductive data analysis approach to derive multiple narrative descriptions, make constant comparisons of, and constantly compare data to bring out meanings and develop a theory (Mihas, 2019). Specifically, TPACK was used to analyse data on how TVET teachers described their TPCK and the TPCK sources that TVET teachers drew upon during the SDL integration of technology. The study followed the analysis process as described by (Braun et al., 2021):

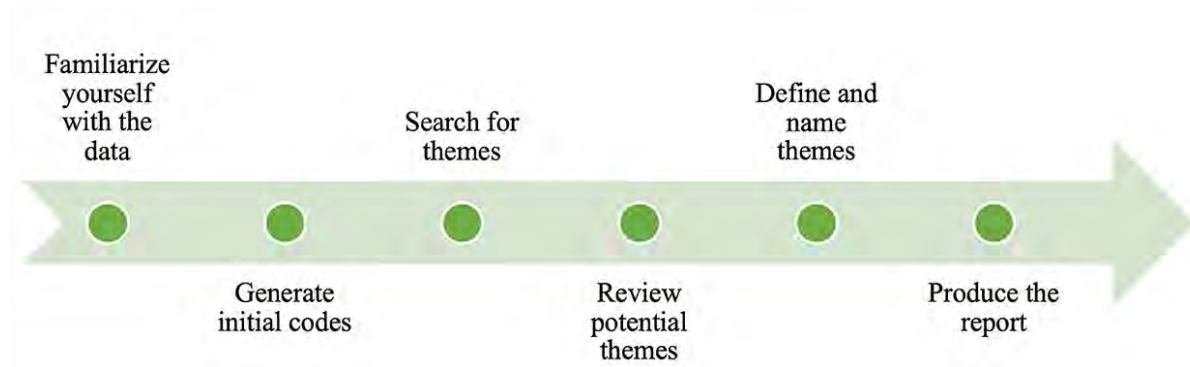


Figure 4.3: Data analysis process

Source: Braun and Clarke (2021)

Mainly, I familiarised myself with the data by reading and re-reading the manuscripts from interviews, observation, and focus group discussions to inductively identify patterns that can be categorised and coded to generate themes and sub-themes on how TVET teachers integrate technology in teaching. Liu (2016) posits that researchers use the inductive data analysis approach to summarise raw textual data, establish the links between the research objectives and the research findings, and use the participants' experiences, views, and meanings to develop a framework. I then reviewed the potential themes defined and named them to make it easy to understand the data.

The SDL emphasis on motivation, autonomy, resource availability, and prior experiences was used as a lens to understand how TVET teachers undertook self-initiated learning within their context and be able to integrate technology in teaching and how they are supported or constrained by self-initiated learning activities to integrate technology into teaching. Therefore, I used qualitative data analysis (thematic) as an analytical tool to examine TVET teachers' knowledge of technological pedagogical content in vocational education technical colleges in Namibia. Braun and Clarke (2021) refer to thematic analysis as a method of data analysis in

which the researchers seek to identify and analyse repeated patterns in the data. Previous researchers have revealed that thematic data analysis allows the researcher to code the responses/data, identify patterns, and generate themes as informed by literature and theoretical frameworks (Hargrove, 2022; Mitchell et al., 2020; Trust et al., 2016).

Moreover, I transcribed transcripts from the semi-structured interviews, focus group discussions, and non-participatory observation using Microsoft Word Software. I supported thematic analysis with the NVivo software version 22 by importing interview transcripts and focus group discussions which streamlined the analysis process. The NVivo software auto-coding function allowed the automatic coding of the data saving time from manual coding of the data. NVivo is a widely used qualitative data analysis software developed by QSR International (Dhakal, 2022; Hilal & Alabri, 2013). Researchers designed the NVivo software version 22 to assist researchers in organising, analysing, and gaining insights from qualitative data, such as interview transcripts, surveys, documents, and audio and video recordings (Mortelmans, 2019). Some of the characteristics of the NVivo software are data import, data coding, data organisation, and querying and searching, among others (Zamawe, 2015).

I used thematic analysis to help achieve this study's goal of understanding the experiences, behaviours, and thoughts of the various cases across the data sets. In addition, the TPACK framework provided a lens to analyse how specific knowledge domains develop and aid TVET teachers in integrating technology into teaching in the VET sector.

During the data analysis phase, I undertook evidence-based decision-making to inform the discussion of the findings and draw up the conclusion for the study because of the data's depth. Using Microsoft Word Software to transcribe data supported by the NVivo software version 22 automated the data analysis process, improving efficiency and reducing the likelihood of making mistakes. Initially, NVivo's automated coding function seemed promising, potentially saving considerable time. However, the reality proved more later as the software excelled at identifying recurring words and phrases in one instance it misinterpreted technical jargons specific to the TVET field, resulting in coding inaccuracies. This necessitated manual verification and correction using NVivo's built-in editing tool, a process that although was necessary it added to the overall workload.

Another unforeseen challenge arose from the incompatibility between NVivo and my chosen audio recording device. To bridge this gap, I integrated Audacity, an audio editing software, into my workflow. This allowed me to process the audio files into a compatible format before importing them into NVivo. Although this workaround proved effective it revealed the importance of considering software compatibility early in the research design phase. Despite these challenges, NVivo ultimately proved invaluable. The software's ability to visually represent connections between themes and subthemes facilitated a deeper understanding of the data. I found the query function particularly helpful, allowing me to quickly retrieve all coded data related to specific topics, thus streamlining the analysis process. Further, using NVivo enhanced the transparency and reproducibility of my research which I believe will allow readers of my thesis to trace my analytical steps, an aspect not always feasible with manual data analysis. My experience with Nvivo reveals both the potential and the limitations of qualitative data analysis software showing the crucial role of researcher reflexivity and the need for continuous refinement of interpretive frameworks.

It is also worth noting that the most significant challenge I encountered involved the inherent subjectivity of qualitative data interpretation. Coding discrepancies arose due to the multiple meanings embedded within participant responses. Some statements fit neatly into multiple categories, making it difficult to maintain clear and distinct thematic boundaries. I also discovered instances where my initial interpretations were skewed by my own preconceptions, highlighting the potential for researcher bias. To mitigate these issues, I engaged in iterative rounds of coding and actively sought feedback from colleagues to refine my interpretations and ensure consistency.

4.11 Validity, Reliability, and Trustworthiness

Validity and reliability are essential when using qualitative methods in case study research.

4.11.1 Validity

Validity concerns the accuracy and authenticity of the study findings (Whittemore et al., 2001). Accordingly, researchers can achieve validity through research instruments used to collect data if they measure what they were supposed to measure (Story & Tait, 2019). To increase the level of validity of the study results, I used questionnaires, interviews, and observation to collect rich data from the six cases. These multiple sources of data collection allowed me to triangulate (comparing the results gathered with other evidence) the data and remove potential biases, ensuring validity (Sumrin & Gupta, 2021). To ensure validity, I conducted a pilot test of the questionnaire with TVET teachers who were not part of the study and a reflective workshop during which participants confirmed the findings and data analysis through member checking.

4.11.2 Reliability

Reliability in qualitative research refers to the stability of responses to multiple coders of data sets. (Sürücü & Maslakçi, 2020). Therefore, to ensure reliability, I kept a reflective journal for field notes from the classroom observations and audio recorded the face-to-face interview and the focus group discussions. I then shared the write-up with more experienced colleagues in the same field of study for review when the data analysis and write-up on each case were complete (Guest et al., 2020). I also presented the study findings at the SAARMSTE Namibia Chapter Colloquium, the SAARMSTE Eastern Cape Colloquium, and the SAARMSTE Conference 2024 in Namibia for critique, comments, and advice.

4.11.3 Trustworthiness

I measured the degree of trustworthiness through credibility, authenticity, transferability, dependability, and confirmability of data in qualitative research. Rose and Johnson (2020) stated that the trustworthiness of qualitative research is determined by the systematic study design, the researcher's reputation, the acceptability of the findings, and the use of proper research methods. Trustworthiness was ensured through data source triangulation and thick description (Whittemore et al., 2001). Using questionnaires, semi-structured interviews,

classroom observation, and FGD to collect data allowed me to compensate for the individual method's limitations and exploit their benefits. Further, the reflective workshop enabled me to verify individual case viewpoints and experiences on technology integration. Since the study focused on multiple cases, the result is transferable to other TVET teachers or contexts depending on the similarity of the contexts and thick descriptions.

While validity, reliability, and trustworthiness of the data were maintained throughout the research process, applying the findings to other settings proved challenging due to the context-dependent nature of qualitative research. Additionally, the small sample size of six participants limited the generalizability of the results. To enhance transferability, I provided rich, detailed descriptions of the research context, participant backgrounds, and study setting. This enables other researchers to assess the applicability of my findings to their own contexts.

4.12 Ethical Considerations

This section details the ethical considerations made in this study. According to Breaux and Smith (2023), every individual possesses inherent worth that necessitates consideration and an essential human entitlement to decision-making a researcher must honour. Research ethics refers to the set of principles and guidelines that govern the conduct of research involving human subjects, animals, or other living organisms (Knight, 2019; Sivasubramaniam et al., 2021). Therefore, incorporating ethical deliberations is critical in research and centres on four principles (privacy, accuracy, property and accessibility) that you must uphold when interacting with participants and data (Schroeder et al., 2019). Further, adhering to ethical standards is crucial to ensure participants' well-being, safety, and rights and maintain the research process's integrity and credibility (Chong & Patwa, 2023; Duggineni, 2021).

4.12.1 Ethical clearance and gatekeeper permission

This study involved human subjects and was therefore prone to considering ethics (McDermott & Newman, 2020). I obtained ethical clearance approval from the Faculty of Education's Ethics Committee at Rhodes University (see Appendix H). This approval authorised me to seek permission from gatekeepers to collect participant data. According to Savolainen (2020), a gatekeeper refers to an individual or group controlling access to a particular community or population researchers want to study. Consequently, I requested permission by sending letters, along with ethical clearance and proposal approval, to the institutions where data was to be collected and obtained gatekeeper permission (see Appendices A, B, and C).

4.12.2 Informed consent and voluntary participation

Before the commencement of the data collection, participants signed informed consent in agreement to provide data through questionnaires, semi-structured interviews, non-participatory classroom observation, and focus group discussions (see Appendices D, E, F, and G). I explained to the participants that their participation in the study was voluntary and that they could withdraw at any time without justification.

4.12.3 Confidentiality, privacy, and anonymity

I assured participants that I would not disclose the collected information but would keep it confidential. I coded the transcripts and used pseudonyms names when presenting data. Furthermore, I stored the data in lockable cabinets and devices, and dissemination.

4.12.4 Integrity, respect, honesty, and transparency

I treated participants with respect, valuing their perspectives and contributions while at the same time allowing them to express their views openly without judgement. Further, I presented the findings honestly and accurately, avoiding selective reporting or distortion of results. Lastly, I acknowledged and discussed any limitations or biases in the research.

4.12.5 Feedback to the participants

I presented the study's findings to the institutions from which I recruited the participants for the study.

Overall, I encountered challenges as some participants were hesitant to provide consent due to concerns about how their data would be used. Additionally, assuring them that their identities would be protected, particularly in sensitive discussions, proved difficult. Maintaining objectivity during data analysis was not easy as it required continuous self-awareness and reflexivity. To address these concerns, I strengthened confidentiality measures by anonymizing responses using pseudonyms and ensuring that all participants signed consent forms. Additionally, I maintained a personal journal throughout the study, recording my thoughts, decisions, emotions, and reflections to enhance self-awareness and minimise potential bias in data interpretation.

4.13 Chapter Summary

In this chapter, I presented the foundational research methodology for this study. Within this methodology, I explored the interpretive research paradigm, which this study was embedded in, to help understand how TVET teachers integrate technology into the VET context. Moreover, I elaborated on the exploratory research design adopted, including the multiple-case study. The chapter further discussed all VET centres as research sites as there was a high chance of not finding instructors who met all the criteria at one VET centre. The chapter elaborated on the simple criterion sampling technique used to select the 25 TVET teachers based on the following specific criteria: must possess more than three years of teaching experience in VET, must have access to technology device(s), must be teaching level one up to three of vocation training disciplines, and must self-integrate technologies into teaching. The specific research process comprising the exploratory and reflective workshop phases guided the study. The chapter also discussed the questionnaire, semi-structured interviews, non-participatory lesson observation, and focus group discussion as data collection tools and data analysis for each phase of the research process. The data analysis process involved thematic analysis, following the approach outlined by Braun and Clarke (2021). Microsoft Word was used for data transcription, and NVivo software (version 22) supported the analysis. The data collection methods highlighted in the preceding sections helped ensure research trustworthiness through data triangulation.

Further, the chapter highlighted how reliability was ensured through reflective journals of observation and field notes, presenting at the community of practice, and sharing the write-up with experts in the field. The chapter emphasised that using questionnaires, semi-structured interviews, FGD, and classroom observation to collect data allowed me to compensate for the individual method's limitations and exploit their benefits. In conclusion, I obtained ethics from Rhodes University's Faculty of Education and TVET institutions to collect data.

CHAPTER FIVE

PRESENTATION AND ANALYSIS OF RESULTS

5.1 Introduction

The previous chapter presented the methodology, including the research paradigm, approach and design, sampling procedures, the data collection instruments, the entire research process embarked upon, and the data analysis used in this study. The chapter further highlighted how I ensured validity, reliability, trustworthiness, and ethical consideration in this study. This chapter presents the findings obtained through data collection and analysis processes and gives a detailed account of the outcomes derived from the research objectives stated in Chapter 1.

The chapter is thus premised on the multiple-case studies that explored the TVET teachers' self-reported practices, experiences, and ways they integrate technology into their classrooms through individual and collective voices. The primary goal of this chapter is to present, analyse, and interpret the study's findings. The data were generated through a closed-ended questionnaire, semi-structured interviews, lesson observations, and focus group discussions. The data generation process spanned nine months, from July 2023 to January 2024. I made the utmost effort to adhere to all the ethical requirements throughout this period.

During the data presentation, analysis, and interpretation, the research questions, the reviewed literature, and the theoretical framework for this study guided the study. The findings from the questionnaire were tabulated with graphs and charts to complement the qualitative data which could be transformed into meaningful insights. This approach enhances clarity, simplifies comparisons, facilitates analysis, supports decision-making, makes the data accessible to a broader audience, and contributes to a clear presentation. The chapter also presents and analyses qualitative findings of the semi-structured interviews, non-participatory classroom observation, and focus group discussion thematically. In the spirit of triangulating the findings, I attempted to consolidate the findings from the various data generation instruments during the results presentation, interpretation, and discussion stages.

Since this is one of the first studies to investigate TVET teachers' TPACK development in Namibia, it is crucial to provide an overview of my encounter with the study participants before presenting the findings. Next is the participants' demographic information, followed by the

presentation and analysis of findings from the questionnaires, and then the presentation of each case involved in the study. A chapter summary then closes the chapter.

5.2 Personal encounter with the participants

As a researcher engaged in data collection, I had the opportunity to interact with various TVET teachers who played crucial roles in shaping my research experiences. These encounters ranged from moments of guidance and support to challenges that ultimately contributed to my research knowledge growth and becoming a scholar in educational technology. The initial encounter with TVET teachers started when I distributed questionnaires during the meeting of TVET teachers at the national office. Then, I introduced myself and the purpose of the study to the selected six participants to secure appropriate dates and times to conduct semi-structured interviews, non-participatory classroom observation, and focus group discussions. I contacted the TVET teachers by telephone, and they all appreciated the gesture. The teachers were happy I was carrying out a study with them on their practices in VET, something they had longed to experience. All the six TVET teachers (cases) I researched during the data collection process were cooperative and informative (see Section 4.8).

I engaged in in-depth discussions about their deep experiences and perspectives with each teacher. These conversations refined my approach and exposed me to alternative perspectives and reflections on teaching practices in VET in Namibia. The teachers' willingness to engage in these discussions demonstrated a commitment to fostering critical thinking and intellectual curiosity. Moreover, the reflective workshops conducted during the second phase of the research process formed a crucial part of this study. As a result, the teachers provided constructive criticism during these workshops, highlighting strengths and improvement areas. These encounters were pivotal in refining my research skills and ensuring the trustworthiness of the data collected.

The participants were willing to be part of the study and promptly signed consent forms to give me access so that I could interview them, observe their lessons, and have a focus group discussion with them. So, their willingness, cooperation, and guidance helped me navigate complex ethical concerns, ensuring that my research adhered to the highest standards. These encounters underscored the importance of moral responsibility in academic pursuits, as reiterated by Jiang (2023).

However, as with any academic research project, there were moments when the data collection process became mentally and emotionally challenging. For example, when it was time to conduct classroom observation, the four participants requested that I act as a peer evaluator for their teaching despite my interest in observing the integration of technologies into the classroom. As per the research process, I planned to observe two lessons. However, most participants requested me to observe more than the two lessons as they felt the study was more aligned with improving their teaching and technology integration. These encounters were a source of encouragement and helped me persevere through difficult phases. Therefore, TVET teachers' willingness to engage in problem-solving discussions and offer constructive feedback was instrumental in overcoming obstacles. This encounter taught me the importance of adaptability and resilience in research.

As I reached milestones in my data collection, some TVET teachers took the time to acknowledge and celebrate these achievements during the reflective workshop. These encounters were a reminder of the collaborative nature of the academic journey and the importance of recognising and appreciating progress. Thus, the study allowed the participants to learn and evaluate their classroom and teaching practices. My encounters with TVET teachers during data collection were diverse and enriching. The interactions were pivotal in shaping my research experience and fostering personal and academic growth.

5.3 Data Presentation from the Questionnaire

5.3.1 Biographic characteristics of participants

The first part of the questionnaire aimed to collect demographic information about the participants' characteristics. This information offered insights into the contexts of VET teaching. In this section, I present and discuss the characteristics of the participants who participated in the study's first phase. The following characteristics of participants are presented: gender, age, colour, discipline(s) taught, the VET level taught, teaching experience, and degrees/certificates attained. It is important to note that I did not use this data as a variable that could potentially influence the development of TPACK. Instead, I present the data to inform the reader of the background of the participants involved in this study.

Table 5.1: Biographic characteristics of participants

Name (synonym No.)	Gender	Age	Colour	Discipline(s) taught	The VET level taught	Teaching experience	Degree (s)/certificates attained	Available/not available for interviews, FGD & classroom observation
1	Male	41-50	Black	Plumbing & Pipe Fitting	1 & 2	11-15	PG Diploma	Not available
2	Male	31-40	Black	Office Administration	Others	5-10	Other	Available
3	Male	41-50	Black	Plumbing & Pipe Fitting	Others	11-15	Bachelor of Education, PG Diploma	Available
4	Male	31-40	Black	Automotive Mechanics	3	5-10	Others	Not available
5	Male	21-30	Black	Automotive Mechanics	2	0- 4	PG Diploma	Not available
6	Female	31-40	Black	Office Administration	3	0- 4	Bachelor of Education	Not available
7	Male	21-30	Black	Horticulture & Crop Production	1, 2 & 3	0- 4	Others	Available
8	Male	31-40	Black	Automotive Mechatronics	1, 2 & 3	5-10	PG Diploma	Available
9	Female	31-40	Black	Metal Fabrication	1, 2 & 3	11-15	PG Diploma	Available
10	Female	41-50	Black	Hospitality & Tourism	1, 2 & 3	11-15	Others	Not available
11	Male	31-40	Black	Electrical General & Solar	1, 2 & 3	0- 4	Others	Not available
12	Male	21-30	Black	Automotive Mechanics	1, 2 & 3	0- 4	Bachelor of Education	Available
13	Male	21-30	Black	Carpentry	1, 2 & 3	5-10	PG Diploma	Available
14	Male	31-40	Black	Office Administration	1, 2 & 3	11-15	Others	Not available
15	Male	51-60	Black	Airconditioning & Refrigeration	1, 2 & 3	26+	Bachelor of Science	Available
16	Male	31-40	Black	Plumbing & Pipe Fitting	1, 2 & 3	11-15	Bachelor of Education	Not available
17	Female	31-40	Black	Mathematics	1, 2 & 3	5-10	Bachelor of Education	Not available

18	Female	31-40	Black	Office Administration	1, 2 &3	11-15	PG Diploma	Not available
19	Male	41-50	Black	Mathematics	1, 2 &3	21-25	Others	Not available
20	Female	31-40	Black	Automotive Mechatronics	2	0- 4	Others	Available

5.3.1.1 Participants gender

The questionnaire required the respondents to indicate their gender based on the following choices: (i) Male and (ii) Female. The analysis shows that out of the 20 participants who completed the questionnaire, 14 participants (n=14, 70%) were males, and (n=6, 30%) were females. This analysis showed that male TVET teachers dominated the VET sector compared to female counterparts. The data seems to contradict Adams and Baddianaah's (2023) findings that there has been a rise in female teachers in TVET across Africa over the past decade. On the other hand, several Southern and East African countries, such as Mauritius, Kenya, Malawi, Tanzania, Rwanda, Seychelles, Uganda, and South Africa, have focused on policies to promote more women taking up teaching and management positions in TVET, especially in male-dominated fields (Bray-Collins et al., 2022). However, despite increased female enrolment and policy support for gender equality, a significant gap exists in implementing gender-sensitive measures in TVET, leading to continued male dominance in the African TVET sector (Akama, 2019; Bala & Khurania, 2023).

5.3.1.2 Participants' ages

The questionnaire asked the respondents to indicate their ages based on preset age brackets as follows: (i) 20 and below, (ii) 21-30, (iii) 31-40, (iv) 41-50, (v) 51-60, and (vi) 61+. Based on the questionnaire analysis presented in Table 5.1, a total of participants (n=11, 55%) were in the 31-40 age bracket, while (n=2, 10%) were in the 41-50 and 21-30 age brackets. Further, only (n=1, 5%) participants were in the 51-60 age bracket. The analysis shows that young teachers between 31 and 40 dominated TVET. The study attributed the dominance of young people in TVET to the fact that they make up the majority of Namibia's population. In addition, only one TVET teacher was in the 51-60 age range because some teachers had gone on early retirement at 55, and none over 60 and more because the retirement age is 60. The involvement of young TVET teachers could be seen as good progress for Namibia as a developing country as compared to the need for new and young VET teachers remained in developed countries

such as Denmark and the Netherlands since more than half of VET teachers were 50 years old or over (OECD, 2021).

5.3.1.3 Participants' race

The questionnaire included a question for the respondents to indicate their race from the given choices: (i) Black, (ii) Coloured, (iii) Indian, (iv) White, (v) Others and None. All participants (n=20, 100%) were black people.

This finding indicated that most of the participants categorised as a previously disadvantaged group during the apartheid era were Indigenous (Bunting, 2006). Therefore, the government has recognised the decolonisation of VET education by creating opportunities and imparting relevant industry skills to the Indigenous population.

5.3.1.4 Discipline taught in VET institutions of the selected participants

The questionnaire asked respondents to indicate the discipline they taught based on the following list: (i) Automotive Mechanics, (ii) Plumbing and Pipe Fitting, (iii) Office Administration, (iv) Bricklaying and Plastering, (v) Carpentry, (vi) Fitting and Turning, (vii) Metal Fabrication, (viii) Electrical General and Others. The disciplines taught in VET differed among the participants, with most participants (n=5, 25%) teaching automotive mechanics, followed by (n=4, 20%) Office Administration, while (n=3, 15%) teaching Plumbing and Pipe Fitting. Two participants (n=2, 10%) taught mathematics. The findings spread the rest (n=1, 5%) over horticulture and crop production, metal fabrication, automotive mechatronics, hospitality and tourism, electrical general and solar energy, carpentry, airconditioning and refrigeration. Table 5.1 shows a high number of five participants teaching automotive mechanics.

It is worth noting that at least each discipline had a dedicated teacher. The findings demonstrated that Namibia's VET provided a variety of disciplines or programmes that aligned with Namibia's economic developments. Examples of programmes are horticulture, crop production, and solar energy. The findings resonate well with Li and Pilz's (2023) study on the international transfer of VET, which states that governments should create standardised VET programmes at the national or global level tailored to emerging economies and value chains, such as specialised VET programmes designed to produce photovoltaic panels used in solar energy generation.

5.3.1.5 The participants' teaching levels in VET qualifications

The questionnaire asked the respondents to indicate their teaching levels and VET qualifications. As stated in Table 5.1, participants (n=13, 65%) taught levels 1 up to 3; while participants (n=1, 5%) taught levels 1 and 2. Only two participants (n=2, 10%) taught Level 2, and another two participants (n=2, 10%) taught Level 3. This is attributed to their experience and qualifications, while (n=2, 10%) taught other levels which were not specified in their responses. The findings also revealed that TVET teachers attained additional qualifications such as a Postgraduate Diploma and Bachelor of Education, which the study argues may have influenced the levels they are teaching. The findings are in line with the Namibian VET report of 2023 that 117 qualifications and 1,894-unit standards have been formulated and are either registered or in the process of registration on the National Qualifications Framework, spanning from Level 1 to Level 6 (Namibian TVET Policy, 2021). Further, Gqili's (2016) study on the doctoral thesis titled "An Analysis of the Occupational Qualifications Sub-Framework in South Africa" posits that Namibia structured its vocational training system around a qualifications framework consisting of ten levels, each aligned with a diploma. Levels 1 through 4 pertain to vocational training, whereas level 5 (Engineering) falls within higher education.

5.3.1.6 Participants' teaching experience

The questionnaire included a question regarding the respondents' teaching experience categorised as follows: (i) 0-4, (ii) 5-10, (iii) 11-15, (iv) 16-20, (v) 21-25, and (vi) 26+. Table 5-1 shows that a total of (n=7) 35% of participants had more than ten years of teaching experience, between 11-25 years, while few participants (n=5, 25%) had more than five years of teaching experience. However, only (n=6)30% possessed less than five years of teaching experience. Moreover, only two participants (n=2), 10%, possessed more than 20 years of experience in teaching. Based on these findings, the study posits that most TVET teachers in this study are seasoned educators who have had ample opportunities to become acquainted with the value of educational technologies and recognise them.

The survey based its argument on the fact that over the past 10 years, the government in Namibia introduced initiatives to include technologies in teaching and learning in VET. The study argues that most teachers who acquired current technological skills would have attended some ICT training, workshops, and conferences as part of their professional development. In

contrast, the findings do not align with Yunus et al.'s (2022) study on technology integration analysis among TVET lecturers in Sarawak.

5.3.1.7 Participants' level of education

The questionnaire included a question regarding the respondents' level of education concerning academic qualification: (i) Bachelor of Science, (ii) Bachelor of Education, (iii) Diploma, (iv) Master of Education, (v) Master of Science, and (vi) Others. Table 5.1 illustrates the dispersal of degree (s)/certificates among VET instructors. Most participants (n=7, 35%) held a postgraduate diploma, although they did not state in which field, while (n=5, 25%) had a bachelor's degree in education. Disappointingly, only six (n=6, 30%) indicated other qualifications without specifying them. More so, only one (n=1, 5%) participant indicated having attained a Bachelor of Science degree qualification. None of the participants stated having a master's degree (Education or Science). Based on the findings, the study noted that most participants possessed the CK and PK acquired through informal and formal training. However, only one participant (n1=, 5%) earned an education degree.

5.3.2 Participants' access and use of technology in the classroom

In this section, I present the data regarding the participants' access to and use of technology in their classrooms. The questionnaire asked whether participants use technology in their classrooms. In response, all participants (n=20, 100%) indicated that they had access to and use technology in teaching. The findings demonstrated that TVET teachers in Namibia have access to technology, whether personal or those provided by the institutions. The findings also revealed that if TVET teachers use technology in their classrooms, then it means that they possess TK. The study argues that participants' access to and use of technology may have enabled them to integrate technology into teaching once they combined it with PK and CK. The finding aligned with Mishra and Koehler (2006), who state that teachers should possess PCK to integrate technology into teaching and content effectively. Nepembe and Simuja (2023) concur with the finding, as their study indicated that TVET teachers' access to technologies encouraged integration in teaching.

The questionnaire also included a question regarding the frequency of TVET teachers using technology in teaching. Figure 5.1 illustrates the findings.

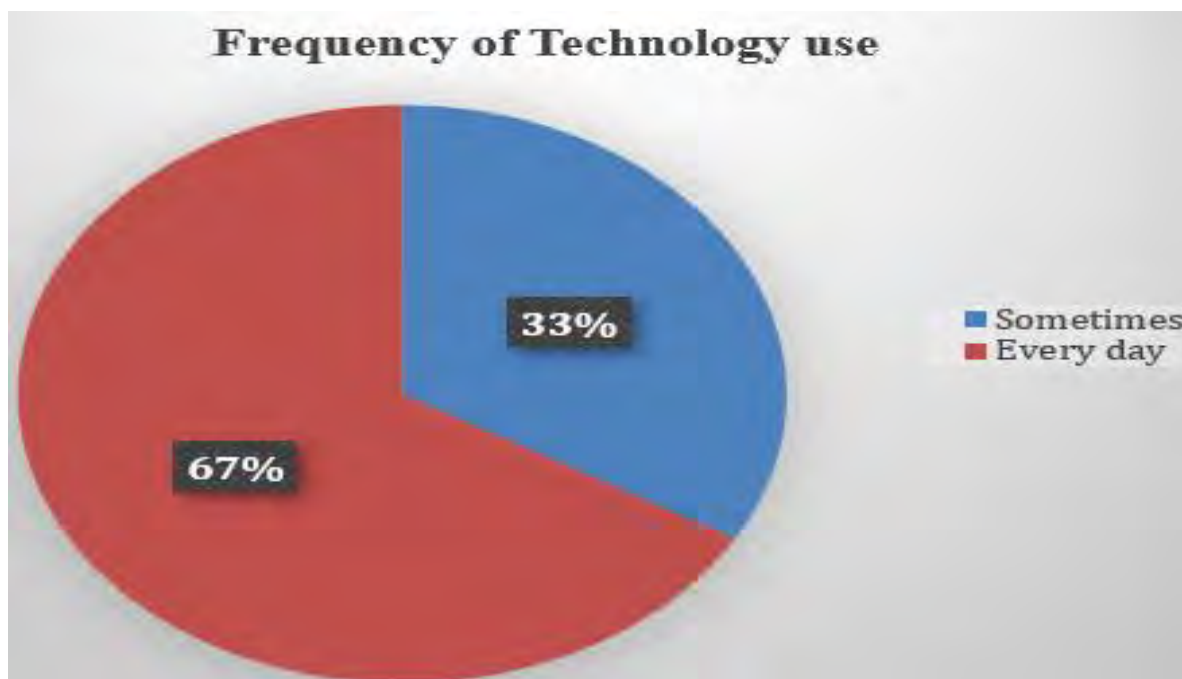


Figure 5.1: Technology use frequency in teaching

Figure 5.1 shows the frequency of technology use among the TVET teachers in the classroom. Some TVET teachers ($n=14$, 67%) expressed daily use of technology, while others ($n=6$, 33%) used it sometimes. The study found that the frequency of TVET teachers' use of technology in teaching was influenced by the availability of technology, skills, competence in technology, perceived benefits, and institutional support. The findings differ from those presented in Winter et al.'s study (2021) where the frequency of use of technology depended on factors such as access to a specific technology, time allocated for lessons, topics to be presented, and students' learning needs. The study argues that the frequent use of technology may have allowed TVET teachers to improve technology integration. The study attributes the finding of 67% of TVET teachers using technology daily to 55% of the participants being between 31 and 40 years old, as presented in Section A, Table 5.1. The finding concurs with Winter et al.'s (2021) study on teachers' use of technology and the impact of COVID-19, which demonstrates that young TVET teachers use technology more often than older ones.

The questionnaire included questions regarding the rationale of using technology in teaching, access and use of some technologies in teaching and learning such as email and LMSs (for example, Moodle, Blackboard, and Google Classroom), and technical support from the VET institutions. I asked the participants to tick the appropriate box regarding how often they used

technology and for which purpose: (i) Never, (ii) Sometimes, (iii) Rarely, and (iv) Every day. Table 5.2 displays the findings.

Table 5.2: Rationale and technological means used for teaching

The rationale for using technology	Never	Sometimes	Rarely	Every day
Search for information	3	2		15
Make presentations for teaching	3	5	1	11
To have students work in a collaborative manner	3	6	1	10
To prepare educational materials	3	3	2	12
Technological means				
Email	4	2		14
School website	6	6	2	6
Learning management system (Moodle, Blackboard & WebCT)	2	5	3	9
Others	2	1		4
Technical support from the VET institution	7	4		9

Based on the findings in Table 5.2 above, the study notes that most participants used technology to benefit teaching and students' learning. The study highlights that using technology in teaching and learning is becoming common and fundamental since most VET institutions in Namibia have installed different technologies (Mässing, 2017). Hence, the findings indicate that 17 TVET teachers used technology to source materials and information for teaching. This finding aligns with Haleem et al. (2022), who argued that with technology, teachers can now access educational resources at any time. For instance, through cloud storage, recorded lectures, and the availability of notes in digital format, teachers have made it more convenient to retrieve teaching materials whenever needed. This approach results in more engaged students, collaborative efforts, and the simultaneous acquisition of technological skills.

Regarding the technological tools the participants used, the findings in Table 5.2 indicated that email was the most frequently used technological tool among participants, with 70% using it daily. The school website and LMS were less consistently used, with some participants accessing them daily while others used them occasionally or not. Many participants still use the LMS daily (45%), though less frequently than email. The findings show varied engagements with different technologies, with email standing out as the dominant communication tool. These findings are congruent with Alkamel and Chouthaiwale's (2018) study on using ICT tools in English Language teaching and learning. Their research indicated

that technological means such as emails, blogs, YouTube, and video conferencing had led to the technological revolution impacting all aspects of user lives, including teaching and learning, and steadily made them more dependable without exception.

Regarding the technical support received from the VET institution, the findings indicated that while a large proportion of participants (45%) often received technical support, a notable group (35%) never had access to it, which may hinder their ability to use technology effectively. The remaining 20% of participants experienced irregular support from the institution. This variation in access to technical assistance suggests discrepancies in institutional support, potentially affecting participants' confidence and ability to integrate technology into their work. This finding concurs with Tondeur et al.'s (2017) study on identifying profiles of pre-service teachers to explore their readiness to integrate technology into education.

5.3.3 TVET teachers' understanding of TPACK

This section presents the findings on TVET teachers' understanding of TPACK. In the questionnaire, I provided TVET teachers with definitions to select the one they believed confirmed their understanding of the TPACK concept. The responses are presented in Figure 5.2 below.

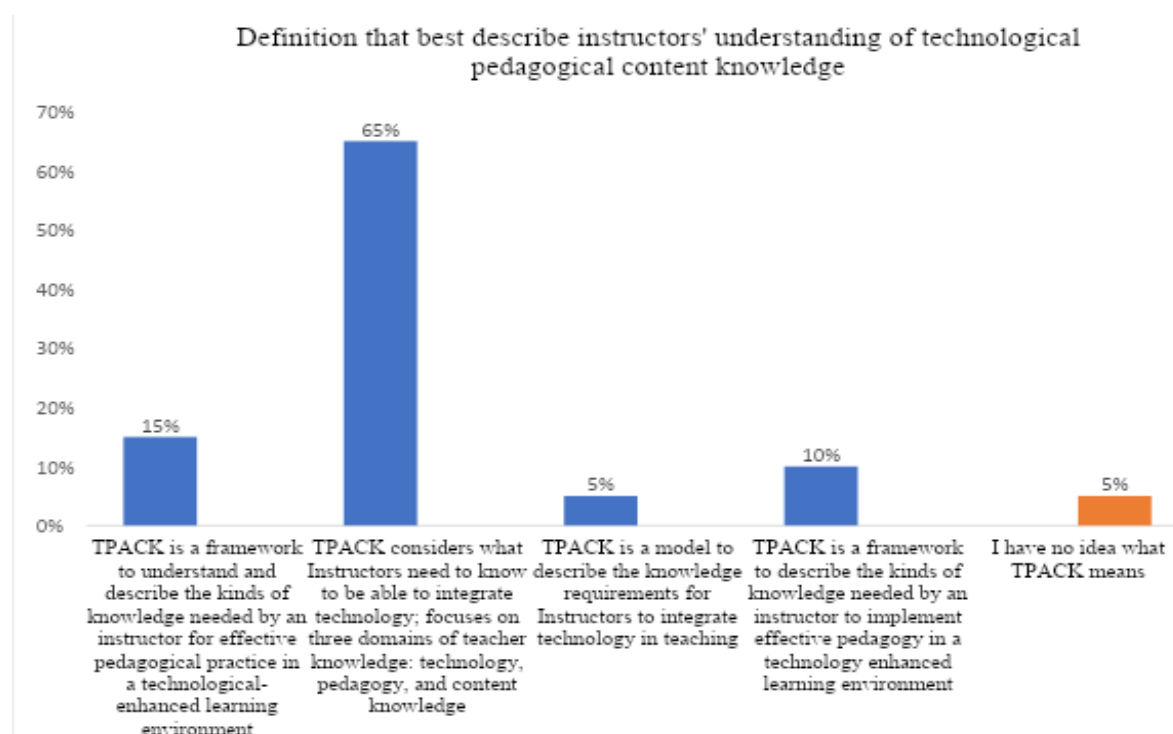


Figure 5.2: TVET teachers' understanding of TPACK

According to Figure 5.2, the findings reveal that while most participants (13) were familiar with TPACK, their understanding of it was incomplete or imprecise, as they did not fully grasp its function as a framework for integrating TK, PK and CK. Only a few participants (5) correctly articulated the meaning of TPACK, understanding it as a framework for effective pedagogy in a technology-enhanced environment. The findings highlight that most TVET teachers lack a comprehensive understanding of TPACK. The study argues that lacking TPACK understanding may impact the TVET teachers' ability to integrate technology into their teaching practices. Therefore, the study findings suggest that TPACK may be an abstract for TVET teachers. The finding aligns with Olayinka, Ngcoza, Simuja, and Shambare's (2023) study on promoting pre-service teachers' TPACK development in an education science course, which found that TPACK was a new concept and form of teacher knowledge.

The study further indicate that there is limited research on technology integration and TPACK development in TVET within developing countries like Namibia which could contribute to TVET teachers' limited understanding of TPACK. This finding concurs with Nepembe and Simuja's (2023, p. 94) study on instructors' perspectives of TPACK in a vocational training classroom in Namibia. They stated that "researchers have not employed TPACK and its associated practices in examining VET instructors' practices in Namibia".

5.3.4 TPACK and technology integration in VET

This section presents data on whether the TVET teachers integrated technology into their classrooms. The questionnaire asked participants to self-report on their TPACK proficiency by responding to Likert-type scale items in the following manner: 1) Strongly Agree, 2) Agree, 3) Neutral, 4) Strongly Disagree and 5) Disagree. Figures 5.3 and 5.4 display the participants' responses below.

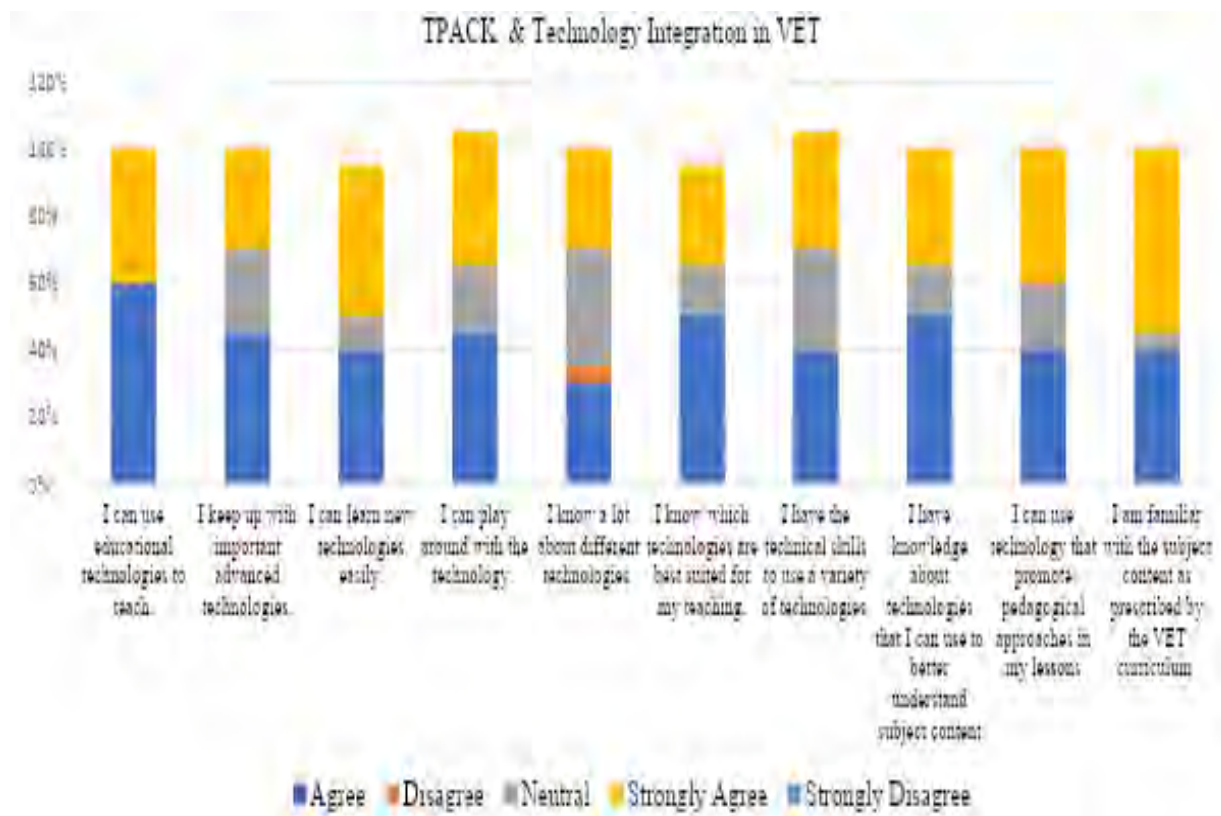


Figure 5.2: TPACK and Technology Integration in VET

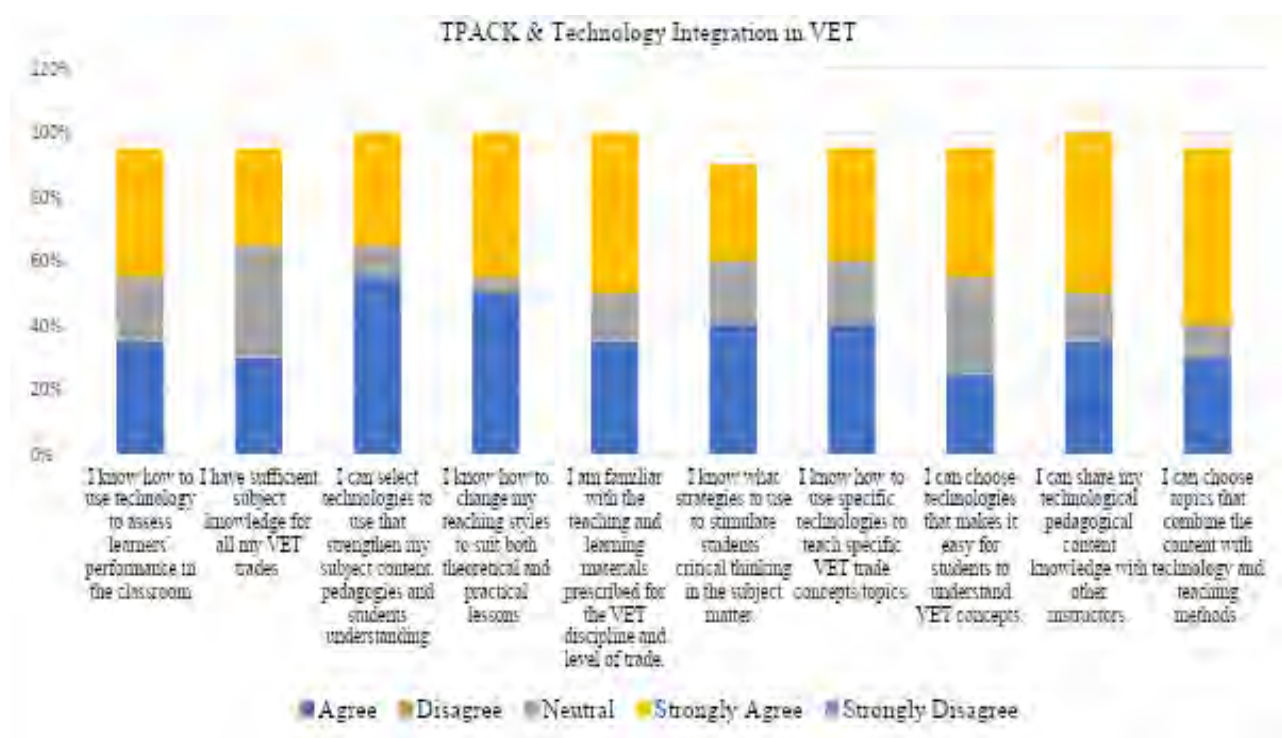


Figure 5.3: TPACK and Technology Integration in TVET

5.3.4.1 Content Knowledge

According to Figures 5.3 and 5.4, most participants (n=16, 80%) agreed and strongly agreed with CK items, such as being familiar with teaching and learning materials prescribed for the VET discipline and level of trade. In contrast, (n=4, 20%) were neutral. Moreover, most participants (n=17, 85%) agreed and strongly agreed to be familiar with the subject content prescribed by the VET curriculum, while few participants (n=3, 15%) reported being neutral. From these findings, the study emphasises that most TVET teachers possessed and were competent in the CK required for their TVET courses. This CK could be traced back to the findings and analysis from Table 5.1 regarding the level of qualifications attained, where TVET teachers acquired their CK. The findings align with those of Kaplon-Schilis and Lyublinskaya's (2020) study on an analysis of the relationship between five domains of the TPACK framework. The findings indicate that CK varies considerably across diverse educational settings, including the distinctions between primary school mathematics and graduate-level mathematics. Teachers are required to attain proficiency in the content they are teaching.

5.3.4.2 Pedagogical Knowledge

Regarding PK items, most participants (n=16, 80%) knew the strategies to stimulate students' critical thinking in the subject matter (n=4, 20%) and how to change teaching styles to suit theoretical and practical lessons. The analysis shows that most participants (n=16, 80%) and a small number (n=4, 25%) possessed PK and could design instructions meeting the diverse needs of their students. The study emphasises that when TVET teachers possess PK, they can deliver instructions more efficiently so that students can understand concepts and stimulate their critical thinking. The findings cohere with Rahmawati et al.'s (2021) study on vocational teachers' perspective towards technological pedagogical vocational knowledge, which highlights that teachers in vocational schools must possess adequate expertise to effectively devise and execute learning strategies that foster the acquisition of the 4Cs (critical thinking, creativity, collaboration, and communication skills) within the specific domains of their vocational skills.

5.3.4.3 Technological Knowledge

According to Figure 5.3, most participants (n=12, 60%) agreed and strongly agreed with most TPACK aspects, such as knowing about technology and integrating it into their classrooms. Other elements are the ability to use educational technologies to teach, learn new technologies,

know which technologies best suit their teaching, and use technology to assess learners' performance. Few participants (n=7, 35%) were neutral with the TPACK aspects regarding TK. Only one participant (n=1, 5%) disagreed with knowing much about technology. None of the participants disagreed or strongly disagreed with the TPACK aspects. An analysis of the study's findings demonstrates that some TVET teachers have developed or possess technological knowledge and skills, which was evident from their responses of agreeing and strongly agreeing to most aspects of TPACK regarding TK. Their responses suggest a level of confidence and familiarity with technologies, reinforcing the presence of technological competence among these educators. This finding aligns with Kazu and Erten's (2014) survey on teachers' TPACK self-efficacy, whose findings show that TK includes knowledge of various technologies and their applications.

5.3.4.4 Pedagogical Content Knowledge

In terms of this construct, Figure 5.3 shows that most participants (n=17, 85%) strongly agreed and agreed to changing their teaching styles to suit both theoretical and practical lessons. However, few participants (n=3, 15%) were neutral. Similarly, (n=13, 65%) strongly agreed and agreed to using pedagogical strategies to stimulate students' critical thinking in the subject matter. In contrast, (n=7, 35%) were neutral. None of the participants strongly agreed or disagreed with the aspects of PCK.

5.3.4.5 Technological Pedagogical Knowledge

With this construct of TPACK, most participants (n=18, 90%) agreed and strongly agreed to all aspects of TPACK concerning TPK, such as using technologies that promoted pedagogical approaches in the classroom and technologies that strengthened their pedagogies. In contrast, (n=2, 10%) disagreed with knowing much about different technologies. This study's analysis revealed that most teachers possessed TPK and understood how to create connections between technologies and pedagogies. The study highlights that the findings reveal that the majority of teachers have a solid understanding of Technological Pedagogical Knowledge (TPK), demonstrating their ability to seamlessly incorporate technology into their teaching approaches. Their ability to establish meaningful links between technological tools and instructional methods highlights their proficiency in using technology to enhance teaching practices. The study highlights that having TPK may allow TVET teachers to balance the technological tools and the instructional designs planned for their lessons. The findings

correspond with Ruiz-Rojas et al.'s (2023) study on empowering education with generative Artificial Intelligence tools. The study argues that understanding TPK may have enabled individuals to grasp how technology could contribute to specific educational objectives, empowering teachers to choose the most suitable tool.

5.3.4.6 Technological Content Knowledge

In terms of TCK, the majority of participants (n=11, 55%) agreed and strongly agreed to know how to select technologies to use that strengthened their subject content and students' understanding; knew technologies that they could use to understand subject content better; learned how to use specific technologies to teach specific VET trade content/topics; could choose technologies that made it easy for students to understand concepts. However, nine (n=9, 45%) remained neutral on all aspects of TPACK. None of the participants disagreed or strongly disagreed with the TPACK aspects of TCK. The analysis of the findings reveals that most participants (n=11, 55%) better understood TCK as they could choose and integrate technology that aided them in presenting content or topics. The study suggests that TVET teachers possess TCK as they can find a link between technology and the content. This implies that these participants are not simply using technology for the sake of it but are deliberately selecting technologies that align with their content requirements. However, it also raises concerns about the other participants whether their limited engagement with TCK stems from a lack of confidence in integrating technology with content or if external factors, such as insufficient resources or training, are hindering their ability to do so. Similar findings were demonstrated in Di Natale et al.'s (2020) study on immersive virtual reality in K-12 and higher education, indicating that technology influenced participants' knowledge by introducing new possibilities for representing content in previously inaccessible ways.

5.3.4.7 Technological Pedagogical Content Knowledge

Regarding TPACK, Tables 5.3 and 5.4 show that most participants (n=15, 75%) agreed and strongly agreed to share their TPACK with other TVET teachers, while (n=5, 25%) remained neutral. In addition, 15 (n=15, 75%) indicated that they could choose topics that combined the content with technology and teaching methods, while five (n=5, 25%) were neutral. Based on the findings presented above, the study notes that most participants (n=15, 75%) possessed TPACK, as they could share that knowledge with fellow TVET teachers while creating a relationship between content, pedagogy, and technology. This indicates a culture of

collaborative learning among TVET teachers, where sharing knowledge contributes to the overall development of technological integration skills. Their capacity to effectively link instructional strategies, subject matter, and digital technologies demonstrates a level of pedagogical flexibility crucial in contemporary education. However, the fact that 25% of participants showed weaker TPACK competencies raises important concerns. This gap could stem from limited professional development opportunities, differences in technological exposure, or varying levels of teaching experience. Addressing these disparities through targeted support and training initiatives would be essential to ensuring that all educators can successfully incorporate technology into their teaching practices. The findings align with Absari et al.'s (2020) study on the effectiveness of TPACK in learning. Thus, with TPACK, teachers integrate and use their understanding of technology, pedagogy, and content to craft meaningful student learning experiences.

5.3.5 Findings from semi-structured interviews and classroom observations

In this section, I present the findings from the participants of this multiple-case study following a similar format. The presentation of each case begins with background information. It explores the data collected and analysed through semi-structured interviews and classroom observations. The interpretation and analysis of data were necessary for data triangulation. Participants were identifiable by their pseudonyms (local) names to protect their real identity, for confidentiality purposes, and for the principles of ethics set by Rhodes University (see Section 4.11). The data was presented based on each research question through the following themes that emanated during data analysis:

- The individual description, understanding, and shifting of TPACK understanding.
- Individual self-initiated learning activities and TPACK development.
- Drivers and constraints for integrating and use of technology in teaching.
- Harmonising the support that initiates the self-TPACK development.

5.3.5.1 Shilongo's case study

Shilongo was a young man between 30 and 35 years old. He was an Oshiwambo speaker born in the Omusati region in northern Namibia. He grew up in an urban area known for its vibrant technology scene. Shilongo was immersed in technology from a young age and exposed to state-of-the-art technologies such as computers, and internet connectivity. He participated in technology clubs and competitions, winning accolades for innovative projects and applications.

Despite living in an urban area, Shilongo's family faced socioeconomic hardships and unemployment and could not afford the financial support for his tertiary education. To help his education and pursue his passion for technology, Shilongo took on part-time jobs. Also, Shilongo's determination and resilience to excel in the technology industry remained strong despite economic constraints. However, due to changes in the education system from Cambridge to Namibia Senior Secondary Certificate, Shilongo could not attain satisfactory grades that would qualify him to pursue higher education in computer science as he initially envisioned. However, that did not bring his hopes down or break him. With the help of his secondary school teacher, Shilongo managed to secure a place at a local VET centre to pursue automotive mechanics.

Shilongo is now a qualified TVET teacher. He has four years of teaching experience in VET and joined the Nekulilo Vocational Training Centre in 2019 as a VET teacher for automotive mechanics. Before joining the VET industry, Shilongo worked as a mechanic for three years in the auto mechanic industry, where he acquired more knowledge and skills in automotive mechanics. He teaches three automotive mechanics modules: diesel, motor, and auto mechanics.

With an extensive background in automotive repair and a passion for teaching, Shilongo brings a wealth of real-world experience to the classroom. As a VET teacher, Shilongo provides students with a comprehensive understanding of automotive technology and repair techniques. Shilongo designed his four-year curriculum to cover various topics, from basic engine diagnostics, designs, and drawings to advanced electronic systems. He ensures students grasp theoretical concepts and gain hands-on experience in the well-equipped automotive workshop.

Shilongo's typical day starts with providing lessons to his students by following a set timetable by the VET centre. Apart from delivering lessons, Shilongo also examines practical and theoretical assessment work for his students to test their understanding and ensure performance. Shilongo does this by providing both theoretical and practical assessments such as tests, assignments, and others. In addition, he also does lesson planning for the following day's topic, whether a new topic or a continuation of the previous day's work.

- **Building a strong foundation in automotive education: Shilongo's comprehensive vocational training curriculum**

Based on the VET curriculum in the first year, the focus is on laying a solid foundation, covering the fundamentals of automotive systems, safety protocols, and basic repair

procedures. He employs a mix of classroom lectures, practical demonstrations, and interactive workshops to engage students and foster a deep understanding of automotive mechanics. In the subsequent years, Shilongo progressively introduces more complex topics, such as advanced engine diagnostics, transmission systems, and computerised vehicle control systems. As I observed during his diesel mechanic class, Shilongo encourages critical thinking and problem-solving skills, challenging students to learn how to troubleshoot and repair increasingly sophisticated automotive issues.

Shilongo understands the importance of staying current with industry trends and emerging technologies. He regularly updates the curriculum with the latest content to incorporate the latest advancements in automotive technology, ensuring students are well prepared for the ever-evolving automotive environment. In addition to technical knowledge, Shilongo emphasises developing soft skills, such as effective communication, teamwork, and professionalism. He understands these skills are crucial for success in the automotive industry, where collaboration and customer service are essential.

Shilongo maintains an open-door policy, welcoming students to seek additional guidance and support outside regular class hours. His approachable character and genuine interest in his students' success create a positive and inclusive learning environment.

By the end of the four-year programme, students under Shilongo's guidance will graduate with a robust skill set and be ready to enter the workforce as competent and confident auto mechanics. Shilongo's dedication to excellence in teaching and his commitment to his students' success make him a respected and influential figure in the vocational education community.

5.3.1.1.1 Individual understanding and shifting of TPACK understanding

One of the questionnaire questions asked Shilongo to select the definition that best described his understanding of TPACK. He answered by selecting b) as indicated below.

Table 5.3: An extract from the TPACK questionnaire for TVET teachers' TPACK understanding

Which definition best describes your understanding of technological pedagogical content knowledge?	
a) TPACK is a framework to understand and describe the kinds of knowledge needed by a TVET teacher for effective pedagogical practice in a technological-enhanced learning environment	

b) TPACK considers what TVET teachers need to know to be able to integrate technology and focuses on three domains of teacher knowledge: technology, pedagogy, and content knowledge	
c) TPACK is a model to describe the knowledge requirements for TVET teachers to integrate technology into teaching	
d) TPACK is a framework to describe the kinds of knowledge needed by a TVET teacher to implement effective pedagogy in a technology-enhanced learning environment	
e) I have no idea what TPACK is	

Shilongo seemed to struggle to understand what TPACK was. He chose b) the definition that explains that TPACK considers what TVET teachers need to know to integrate technology, focusing on three domains of teacher knowledge: TK, PK, and CK. This definition, which Shilongo selected as the standard, does not correctly relate to the standard definition of TPACK.

In his semi-structured interview response, Shilongo stated:

TPACK is new to me. I need to understand the TPACK framework and how it relates to my teaching context better. I cannot believe I even struggle to pronounce technological pedagogical content knowledge, especially if I had to say it fast. During pre-service training, lecturers only referred to technology, not a combination of expertise as TPACK comprises.

The quote above shows that the TPACK concept is an abstract to Shilongo despite growing up in a technology-rich environment and being fully prepared for pedagogy and content during his pre-service training, which included educational technology as a module. This implies that the VET teaching context may have overlooked mainstream educational practices related to technology diffusion because the VET context differs from other education training. After all, it involves working with machines and equipment, which is considered technology. Hence, there is a need for a TPACK that fits its unique settings. The limited research on VET, especially in Namibia, and most VET teachers' exposure to such studies from elsewhere added to the puzzle. The study argues that Shilongo may struggle to understand TPACK because he is unfamiliar with the TPACK framework. However, Shilongo (looking at the TPACK acronym) acknowledged the three knowledge constructs required for effective teaching and technology integration: technology, pedagogy, and content and, he stated:

It is evident that a teacher must be well-equipped with subject knowledge while also understanding how to effectively deliver it to students. As technology continues to advance, it has become an integral part of this process and cannot be overlooked.

The quote underscores the need for teachers to have a solid understanding of their subject matter and the ability to teach it effectively. It also highlights the increasing significance of technology in education, indicating that teachers must adapt to technological developments and incorporate them into their teaching methods to remain relevant and effective. Technology has become an essential element of contemporary teaching rather than an optional addition.

Shilongo seemed confident that understanding TPACK would improve his ability to collaborate with his students, other TVET teachers, and technology experts to develop innovative and effective teaching strategies. Shilongo's understanding of TPACK changed through the study as he became aware of the conceptual and knowledge relations between technology, content, and pedagogies, he stated during the interview:

I cannot believe what has just happened to me. It looks as if I woke up from a deep sleep. It is interesting to follow the discussions about TPACK and reflect on what you know but could not relate to TPACK then. From here onward, the sky is the limit.

The quote reflects Shilongo's recognition of his limited understanding of TPACK, while also conveying his gratitude for the chance to expand and deepen his knowledge of the framework.

During the semi-structured interview, Shilongo was asked to place a tick (✓) on the TPACK diagram to indicate his TPACK. Figure 5.5 shows an extract of the question from the semi-structured interview schedule.

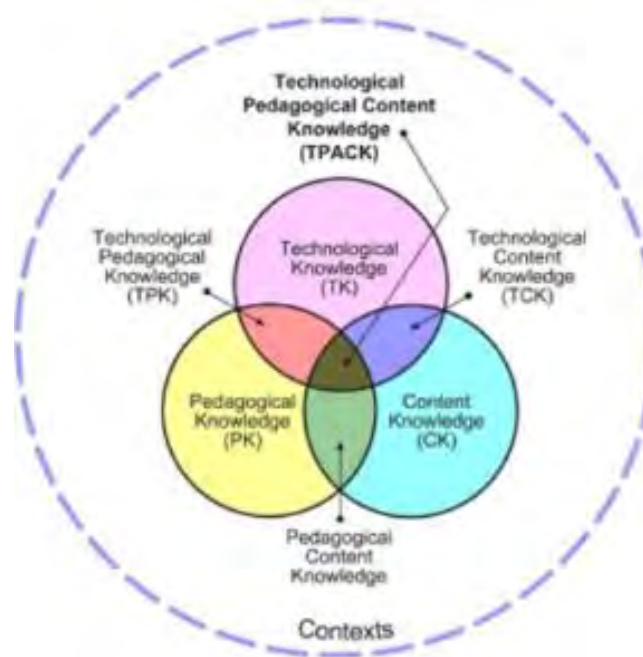


Figure 5.4: An extract of the TPACK diagram from the semi-structured interview schedule

Shilongo placed a tick on CK and PK, then TK. The finding demonstrates that Shilongo is adequately prepared in terms of instructional methods and subject matter, which, according to him:

I acquired my CK during my VET training as an auto mechanic and my pedagogical practices after I enrolled for a bachelor's degree in education. It is CK and PK that allowed me an opportunity to prepare and join VET as an instructor to teach others.

The quote suggests that Shilongo's experiences and knowledge lay more in CK and PK. However, he admitted that he was not very technologically advanced. Still, he was confident and optimistic that his natural TK and the technology-rich environment he grew up in helped him to use technology and integrate technology into his teaching. In addition, Shilongo separately and independently integrated technology into his classroom, strengthening his TK, CK, and PK. The study's findings demonstrate that Shilongo seems to understand the different knowledge domains (technology, pedagogy, and content) and how to balance and link technology to content and pedagogy. Therefore, Shilongo's choice of CK, PK, and TK demonstrates that he is acquainted with his TPACK because he is strong on technology, pedagogy, and content. Classroom observations revealed that Shilongo has a strong grasp of CK, PK, and TK. His thorough knowledge of the subject matter and his effective use of

technological devices to explain concepts to his students highlighted his ability to integrate CK, PK, and TK seamlessly.

When asked about his view of the “T” position in TPACK concerning vocational training disciplines, Shilongo revealed that the T is well known among most VET teachers, as he believed that TVET teachers need to acquire TK simultaneously as PK and CK. He acknowledged not being technology-oriented and advanced despite his background in technology but learnt from himself and fellow TVET teachers. He would have wished for the “T” to be acquired last. Still, creating an interaction between technology, pedagogy, and content would be difficult, which is essential for effective teaching. This finding highlights that Shilongo expected the “T” position in TPACK to change depending on the context. However, this view depends on the individual VET teacher’s perspective and the circumstances surrounding that individual. Shilongo explained his view during the semi-structured interviews as follows:

There is no better time to learn and acquire technological knowledge than during pre-service training, which is concurrent with pedagogy and content. Although I had access to technology throughout my growing-up era, I still needed the grips on technology integration and creating a balance between the knowledge domains. Therefore, the “T” position should remain as is.

I would have wanted the “T” concerning vocational training disciplines to be somewhere between pedagogy and content in TPACK; however, in this case, CK is supposed to precede PK” because I believe one should first have the subject knowledge before knowing how to teach others.

Aaaam! There is a difference between knowing how to operate technological devices and integrating technology.

The excerpts above expresses the view that pre-service training is the perfect opportunity for teachers to gain technological knowledge in parallel with pedagogy and content expertise. Shilongo recognises that, although he was exposed to technology during his upbringing, he still needed to learn how to integrate it effectively into his teaching. He also distinguishes between simply knowing how to use technology and actually incorporating it into teaching practices, stressing that effective use of technology goes beyond just being familiar with them.

So, during the semi-structured interview, I asked Shilongo how he uses technology in teaching, explicitly integrating technology into his teaching. He enthusiastically agreed to integrate innovative technology into his classes, recognising its potential to enhance student engagement and learning. The technology he uses includes the technologies available at the institution, such

as Blackboard, a LMS, projector, laptop, internet, and flip chart; technologies owned by students, such as mobile phones and protractors, rulers, and his own technologies, such as a laptop and smartphone. He mentioned:

There are many technologies available for use in the teaching and learning process. However, their use depends on both the availability of these technologies and the knowledge to operate them. For example, I can only use technologies such as Blackboard, an LMS, a projector, laptop, internet, and flip chart because these are the ones I have access to and know how to use.

The quote emphasises the significance of both having access to technology and possessing the necessary skills to use it effectively in teaching and learning. Shilongo notes that, although numerous technologies are available, their actual use in the classroom relies on two key factors: access to the technology and the ability to operate it. This implies that a teacher's capacity to integrate technology into their teaching is shaped by both the availability of resources and their technological proficiency.

During his lesson observation, it was clear that Shilongo confidently uses technology because he views every tool, machine, and piece of equipment as part of technology, which aligns with the technical and technology-oriented nature of his trade in auto mechanics. Shilongo acknowledged that although he uses digital technology less frequently in class, he only uses it sometimes. Shilongo explained during the semi-structured interviews:

Using technology in teaching depends on the topic planned for the specific day and the pedagogical practices. Especially here in VET, we do not use technology to teach all modules or content.

The above quote suggests that Shilongo has experience teaching the TVET curriculum and is trying to identify topics to use and integrate technology. The quote further highlights Shilongo's understanding of the need to be conscious of pedagogies and content that require incorporating technology. The study argues that Shilongo could adapt the technology for different subject content and contexts and integrate it by aligning it with his pedagogical approaches. However, Shilongo admitted that he has not received or attended any training to acquire TK, specifically on technology integration into the subject area, but growing up in a technology-rich environment with access to technologies helped him understand basic technology and use technology in his classes. Furthermore, Shilongo acknowledged having undertaken self-initiatives to learn some technologies from YouTube and from some students who shared some knowledge of technologies. All these aspects enhanced his TK, specifically

integrating technology into his classrooms. Thus, he could take charge of his learning by independently exploring and accessing various technologies.

During the semi-structured interviews, I asked Shilongo the reasons for using technology, and he indicated that he primarily uses technology to prepare educational materials for his students and pressure to meet the learning needs of students in his classroom. Shilongo also uses technology to search for information and allows students to work collaboratively. The scarcity of learning and teaching materials is a concern in most VET institutions in Namibia, as noted by Shilongo:

Eish, there are insufficient educational materials in VET; even with adequate materials, the content is patchy and unclear. Thus, I must search online for information to prepare for lessons. Educational materials for VET, especially for technical trades/disciplines, are not published and sold in bookshops like those in mainstream education. Therefore, having information and content to teach my students poses challenges.

From the quote above, Shilongo seemed to underscore the issue of inadequate educational materials. He further explained:

I attribute the issue of inadequate educational materials to how material developers develop them. These materials are created by the graduates of the specific discipline, depending on the VET levels they have completed. They may not be bold enough and experienced enough to do so. The situation has prompted VET teachers to find alternative ways to obtain relevant lesson information.

This quote indicates that the challenge of insufficient educational materials in vocational education and training (VET) arises from the way these materials are created. Shilongo links this issue to the fact that the developers of these materials are typically graduates of the relevant discipline, whose experience may not be adequate to produce high-quality, effective resources. Shilongo also suggests that these developers might lack the confidence or expertise required to create comprehensive and effective materials.

Shilongo revealed that he uses the internet and technologies like email, school websites, YouTube, and Blackboard to search for information and integrate technology into lessons.

During the semi-structured interview, Shilongo admitted that he could not use technology to teach all his modules because those modules require hands-on experience. In this regard, he explained:

It is not easy to teach, i.e., manual dexterity and hands-on skills using technology, so I demonstrate on the board because the topic deals with how students are to manipulate tools, handle components, and physically work on vehicles, which require hands-on practice.

This quote highlights the difficulty of teaching practical skills, especially in vocational fields like manual dexterity or technical tasks (such as using tools or working on vehicles), when attempting to incorporate technology. Shilongo notes that, because the subject requires hands-on work and physical interaction with technologies, demonstrating on the board is more effective than relying exclusively on technology. This underscores the limitations of technology in teaching skills that require direct, physical practice and real-world application.

The questionnaire included a question for the participants to self-report on their TPACK. When asked to self-report his TPACK and technology integration in VET, Shilongo expressed his TPACK proficiency by responding to Likert-type scale items, assigning values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

Shilongo agreed and strongly agreed with most aspects of TK, PK, and CK. For instance, Shilongo strongly agreed that he could learn new technologies quickly, knew which technologies were best suited for his teaching, and could use educational technologies to teach. The findings converge well with placing his TPACK on CK, PK, and TK, which spilt into TPK and TCK. The study argues that Shilongo's natural technology knowledge may have contributed to his TK. Shilongo also self-reported being neutral with CK regarding having sufficient subject understanding for all his VET trades and being familiar with the teaching and learning materials prescribed for the VET discipline and level of trade.

Similarly, on PK's items, Shilongo indicated that he knew how to change his teaching styles to suit theoretical and practical lessons. The study demonstrates that VET teachers such as Shilongo need to adapt, revise, and update their CK (subject knowledge) as the curriculum changes. The findings indicate that Shilongo should regularly engage in SDL on the latest content and pedagogical practices, primarily through online courses and workshops, to keep up with the evolving needs of VET education and its students. This finding also aligns with the classroom observations and semi-structured interviews where he showed subject solid knowledge, as he explained and demonstrated when teaching technical drawing. Figure 5.6 below indicates Shilongo explaining technical drawing on the whiteboard while holding a set of squares to draw the diagram.

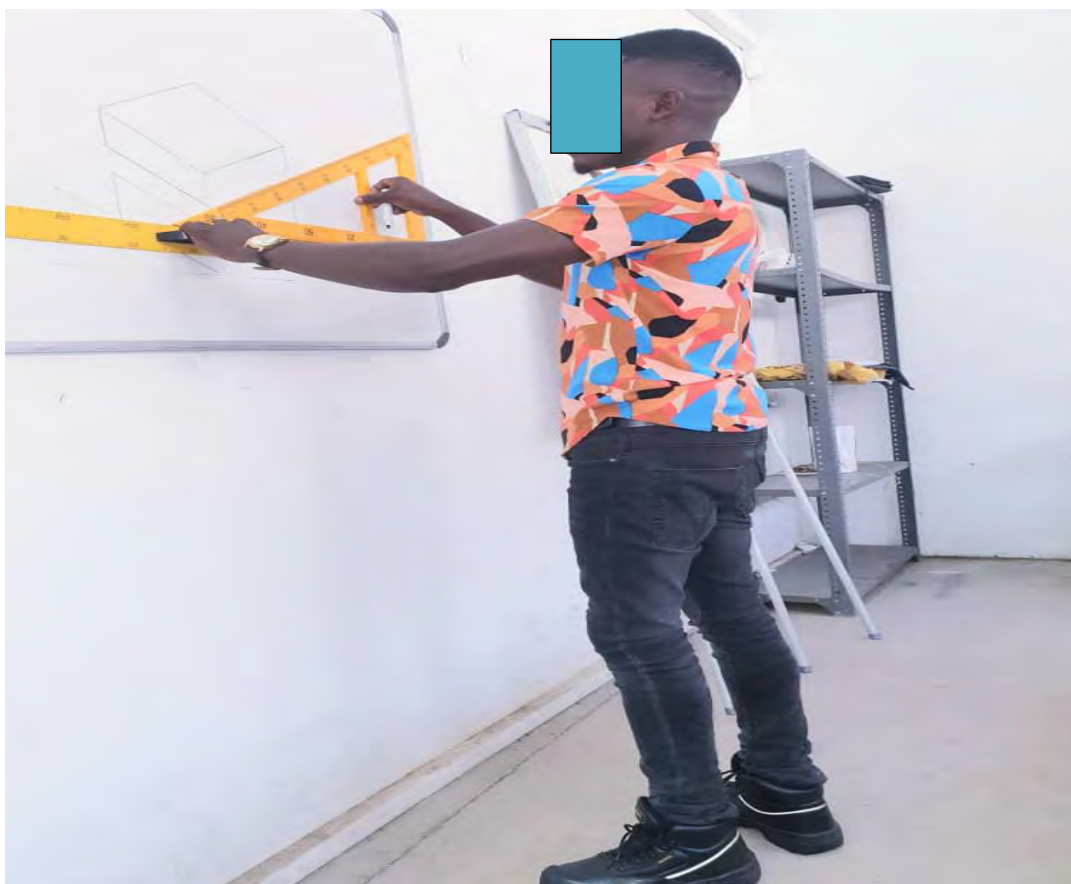


Figure 5.5: Shilongo explaining technical drawing during a class

Moreover, Shilongo also agreed to aspects of TCK, indicating that he knows and is aware of technologies that he could use to teach subject content better. He said he chooses technologies that make it easy for students to understand his subject's concepts. At the same time, regarding PCK, Shilongo narrated that he knows the strategies to use to stimulate students' critical thinking in the subject matter. He further expressed that in most contexts of his teaching, he selects technologies that strengthen his subject content and pedagogy experience and shares his TPCK with TVET teachers. Shilongo explained the situation as follows:

I cannot believe that my upbringing impacted my life and career. Growing up in an environment where I was exposed and had access to some technological devices equipped me with technological skills and knowledge, which are essential in my classroom today. I can do what I can in my teaching because of all that happened early in my growing-up years.

This quote reveals the Shilongo's recognition of how his early access to technology shaped both his personal and professional growth. Shilongo acknowledges that the skills and opportunities gained during their formative years have enabled him to effectively integrate

technology into teaching, emphasising the enduring impact of early technological exposure on his career.

When asked during the semi-structured interview about some instances that drew him to use technology, Shilongo explained that a lack of teaching and learning materials prompted technology integration into teaching. For example, he expressed himself as follows:

When teaching technical drawings, I need to follow specific steps. With the help of my PC, I use YouTube videos to access and download all the steps and demonstrate and explain them to students on the board in the classroom. These steps are not well detailed in the teaching materials at my disposal, as on YouTube.

This quote demonstrates how Shilongo leverages technology, particularly a PC and YouTube, to improve the teaching of technical drawings. Shilongo points out that while available materials lack detail, YouTube offers more comprehensive resources, allowing for better demonstrations and explanations in class. It highlights how technology can enhance teaching quality, especially when traditional resources are insufficient.

During the technical drawing in the diesel mechanic lesson, I observed a few technologies in the class, ranging from a whiteboard, a mobile flip chart, students' protractors, and Shilongo's android (smartphone). I noted that Shilongo and his students had access to technologies that supplemented those provided at the institution. Moreover, I observed that students in his class were allowed to use personal technologies, such as laptops and mobile phones, to participate in some classroom activities. For instance, I also observed that Shilongo used both the whiteboard and the flip chart maximally to demonstrate to students the procedures of drawing the four-squared diagram using the geometrical construction instructions. These were the same technologies Shilongo mentioned during the focus group discussion. Therefore, the study attributes the few technologies in Shilongo's class to the fact that Nekulilo Vocational Training Institution started its operation in 2017 and is yet to acquire most of the technologies needed for teaching.

When asked during the semi-structured interview how he integrates technology in teaching, Shilongo described his technology integration experience as growing up in an environment that offered access to digital technologies; he posited:

I now possess technological skills and combining them with the subject content and pedagogical practices has allowed me to integrate technology into teaching. I can create a relationship between technology, pedagogy, and content while adapting pedagogical practices and content responsive to students' needs.

The quote highlights Shilongo's understanding of the importance of blending technology with subject knowledge and teaching strategies. By merging his technological skills with expertise in pedagogy and content, he can adapt the approach to better meet students' needs, effectively applying TPACK in practice.

Shilongo acknowledged learning from himself, colleagues, and students and knowing which technologies best suited his teaching. His technological skills allow him to search for information on the internet to aid in his teaching and explain abstract concepts in detail to students. Shilongo explained that he uses technologies to complement the pedagogical approaches he applies in his lessons. For example, he stated:

I use online platforms like the LMS to share resources, assignments, and instructional materials with students when teaching technical drawing. Those platforms allow me and the students to create discussion forums and collaborative tools promoting interaction and knowledge sharing. Furthermore, I direct students to various web-based drawing tools and applications that allow them to develop technical drawings directly in their web browsers. These tools must do as they come with collaboration, sharing, and feedback features, making the learning process more interactive.

The quote demonstrates that there is interaction through discussion forums and collaborative tools. Moreover, the integration of web-based drawing tools boosts student engagement by enabling them to create and share technical drawings, cultivating a more interactive and collaborative learning atmosphere.

In addition, I observed in one lesson that while Shilongo demonstrated some concepts on the whiteboard using a projector, students were busy using their A3 plain papers that Shilongo distributed at the beginning of the lesson and their protractor to practise and mimic him. The study argues that Shilongo did not integrate technology into teaching alone but collaboratively worked with the students because students showed Shilongo what to do and how to take the drawing measurements.

When asked how technology has assisted him in designing assessment tools (question papers, worksheets, and so on), Shilongo admitted that apart from using technology to draw content to teach his students, he also uses his technologies to model some sample assessments from the internet and manage student assessments through Blackboard. He posits, "*I also design marking rubrics for activities, assignments, and examinations*". He narrated that technology simplifies the marking and recording of grades for his students as he uploads the memorandum

and marks on Blackboard. He also sometimes sends instructions and content to students via WhatsApp, a social media technology.

When asked during the semi-structured interviews how VET's ICT training on technology changed his pedagogical practices, Shilongo revealed that the knowledge gained from technology has not really supported his approach to using technology in teaching and accessing relevant information. He expressed that the two ICT training sessions were not subject-specific. They were meant to introduce the VET teachers to Microsoft Office packages.

He also reminisced that the pedagogical practices he uses to teach have improved due to using some content sourced from YouTube. He narrated:

Now that technology is at my doorstep, it has pushed me out of my comfort with traditional teaching methods to adapt and learn how to integrate technology into teaching. I also embrace self-learning because it allows me to learn at my own pace without anybody pushing me.

The quote highlights Shilongo's awareness of how technology has pushed him to step outside traditional teaching methods and embrace new ways of integrating technology. It also emphasises his appreciation for self-learning, as it provides the freedom to learn independently and at his own pace.

I noted that Shilongo and the students' engagement and interactions were high during the classroom observation. Shilongo interacted with the students through questions and feedback. The interactions between Shilongo and his students enhanced the students' understanding of drawing the four-squared diagrams using the geometrical construction instructions.

5.3.1.1.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Shilongo indicated that he acquired his CK from pre-service training as a VET trainee. However, when Nekulilo Vocational Training Institution appointed him as a TVET teacher, he realised he lacked knowledge of teaching methodology. That realisation encouraged him to enrol in an undergraduate bachelor's degree in education, a teaching qualification from which he drew his PK. He related the matter as follows:

I knew well that I lacked PK because the TVET training prepared us to be industry experts and not teachers, as it turned out to be. So, enrolling in a course to acquire pedagogical knowledge was the right decision I have ever made.

During classroom observation and lesson planning, the study noted that Shilongo was well acquainted with the subject matter and pedagogical practices. He began his class by reflecting

on the previous day's lesson, asking students questions, and introducing the lesson. Figure 5.8 shows Shilongo's lesson plan below.

LESSON PLAN

a) Institution: §	Trainer:
Learning area: TRADE AREA OF STUDENT	Level: 2
Date/week: 09.01.2024	Duration: 1H 30 MIN
Context: GEOMETRICAL CONSTRUCTION	
Specific Learning Outcome: Usage of drawing instruments, Bisect an angle, <u>Construct</u> a parallel line to a straight line, Construct a circle outside a given triangle, Construct a circle inside a given triangle and Construct of ellipse.	
Lesson Objectives: Construction of the Ellipse by method of spring bow compass (Four-centre method).	
Teaching method: <u>demonstration and group work.</u>	
Assessment Strategies: Class Activity	
Trainee Activities: Listening, taking notes, and asking questions.	

Time	Process steps	Trainer activities	Trainees' activities	Resources
10 min	1. RECAP ON PREVIOUS LESSON What are the procedures for holding a pencil when drawing freehand?	Asking questions on the previous topic: What are the procedures for holding a pencil when drawing freehand?	Trainees sign the attendance register. Answering questions.	Whiteboard ~~Whiteboard~~ marker T-Square
30 min	2. INTRODUCTION GEOMETRICAL CONSTRUCTION Geometrical construction is going to be based more on how to bisect different angles. the word bisect itself means to be divided into two equal parts.	Introduce the topic State importance State the objectives	Questioning and answering Taking notes	White board Whiteboard marker T - Square

Figure 5.6: An extract of Shilongo's lesson plan for auto mechatronics

Figure 5.7 depicts that Shilongo's lesson objectives were clear and aligned with the day's topic. Both the trainer's and trainees' activities were stipulated, and the resources, which were technological tools, were planned for the lesson. Shilongo also highlighted the resources for the lesson, including the whiteboard, whiteboard marker, and T-square. Such activities led to Shilongo drawing upon CK and PK from the pre-and in-service training compared to TK. The study argues that by using geometrical construction instructions, along with his CK, PK, and TK, Shilongo could connect pedagogical strategies when drawing the four-square diagram. He expressed:

I like having a lesson plan in place as it provides a structured framework for me to organise and deliver subject material effectively, ensuring that essential learning objectives are achieved within the allocated time. I ensure that each lesson component, including instruction, activities, and discussions, is allocated sufficient time.

The quote shows that Shilongo values lesson plans as a methodical way to organise and deliver lessons. It emphasises his commitment to achieving the key learning objectives within the allocated time by carefully managing the time for each part of the lesson, including instruction, activities, and discussions.

Regarding the in-service, Shilongo acknowledged that his teaching experience also contributed to his CK and PK. Therefore, Shilongo's CK and PK, shaped by his teaching experience and self-learning, informed his PCK. The study suggests that despite the formal education Shilongo underwent from which he drew his CK and PK, he self-learned to improve his knowledge and skills, bringing them on par with current trends and developments in teaching. The study noted that when Shilongo self-learned to improve his technological expertise and abilities, it also supported improvements in CK and PK and aligned with the VET curriculum.

Shilongo also highlighted drawing some of his TK from students who shared their expertise and knowledge on some technologies. Sometimes, the students helped him select appropriate technologies that were freely available online and aligned with learning specific concepts and content. Shilongo further narrated that he also learned how to use technology (TK) from fellow TVET teachers who integrated technology into their classrooms. The assistance included learning and being supported by colleagues in choosing better technology suitable for teaching some topics and pedagogical practices. So, Shilongo stated:

I appreciate the WhatsApp group we created with TVET teachers from various VET institutions teaching the same trade. All information, questions, and problems relating to teaching the auto mechanic trade are raised and discussed, and they have helped me learn some of the concepts and materials I was unaware of.

The quote above also indicates that Shilongo was part of a community of practice that used WhatsApp groups. Shilongo added that through this community (Whatsapp group) of VET teachers, they also organised workshops to discuss issues concerning their unique teaching fields, share knowledge and information, and create opportunities for collaboration in teaching and finding best practices for integrating technology into education.

5.3.5.1.3 Drivers and constraints for integrating and using technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

During the semi-structured interview, Shilongo was asked to describe the self-initiated learning activities that may have helped him integrate technology into teaching, and he appreciated using technology as it benefited him as a VET teacher and for the students. In addition, Shilongo stated that one drive for him to integrate and use technology in teaching was having access to a laptop, which he used to access subject content via YouTube educational videos. He stated that engaging educational materials, including e-books, online articles, videos, and interactive simulations, encouraged some VET teachers to explore these resources to understand the subject matter better. Shilongo said thus:

The use and integration of technology have allowed me to access various online sites from which to download subject content and other relevant materials like assessment samples. For example, searching for information on the internet gives me loads of content from which I can select the one I am looking for. Therefore, I use e-books, online articles, YouTube videos, and study guides to aid lesson planning and actual teaching, prepare assessment tasks, and thoroughly examine students' performance.

This quote emphasises how the use of technology has broadened the teacher's access to various online resources, including e-books, articles, YouTube videos, and study guides. Shilongo highlighted that learning from YouTube videos and other online content supported helped him become innovative and present complex topics to students. However, he emphasised that self-learning had its weaknesses and challenges; thus, he narrated during the interviews:

I once got frustrated self-learning how to calibrate a vehicle's On-Board Diagnostics (OBD-II) systems. It was difficult for me to understand the in-depth technical intricacies of these systems. So, I had to engage professionals and access the VET Global channel on YouTube.

Shilongo emphasised that the frustration experienced during self-initiated learning of some technologies and content could be demotivating as he became overwhelmed and felt inadequate while trying to understand and apply concepts. The study suggests that personal motivation is critical during self-learning as it is a shield to completing the learning process.

Furthermore, Shilongo indicated that self-initiated learning lacked immediate feedback and support that fellow TVET teachers and teachers could provide to facilitate the formal learning environment.

He explained:

Sometimes, when I misunderstand a concept, I do not easily find alternative interpretations for better comprehension, leading to reluctance to learn independently. So, with self-learning, there is usually no one else to inquire from for clarity.

The quote shows that Shilongo values lesson plans as a methodical way to organise and deliver lessons. It emphasises his commitment to achieving the key learning objectives within the allocated time by carefully managing the time for each part of the lesson, including instruction, activities, and discussions.

Moreover, Shilongo underscored time constraints with self-initiated learning, as his schedule was overwhelmed by teaching, administrative duties, and continuous professional development; he stated, “*I always have a demanding schedule*”. Shilongo further explained:

The extra responsibility of self-initiated learning can be perceived as an additional pressure source. When educators perceive themselves as lacking adequate time to engage with self-learning materials effectively, they may experience frustration and a loss of motivation, regarding the learning process as an overwhelming challenge rather than a beneficial opportunity.

This quote highlights how the additional responsibility of self-directed learning can become an overwhelming burden for Shilongo.

Shilongo expressed that another constraint to integrating and using technology in teaching was the lack of adequate infrastructure, such as reliable internet access and modern equipment, which can limit instructors’ and students’ ability to thoroughly use digital tools for learning. Some TVET teachers are in centres in remote areas or have recently established and have yet to acquire technological infrastructure.

5.3.5.1.4 Harmonising the support that initiates the self-TPACK development

This section presents the support Shilongo believed would help him integrate technology into teaching. When asked during the semi-structured interview about the support he required to incorporate technology into teaching, Shilongo mentioned regular and continuous engagements with other TVET teachers through ICT workshops and seminars, which would always greatly support them in refreshing their skills and improving their teaching strategies. He highlighted that the National Training Authority (NTA) should organise these workshops and invite experts in the field for facilitation. He stated:

NTA collects a training levy from the industry from which a portion of this money can be directed towards institutional investment in infrastructure and resources, such as reliable internet access, updated hardware, and software licenses, to create a conducive environment for technology integration.

The quote shows that TVET institutions could potentially afford technological infrastructure, as the NTA collects a training levy from the industry.

The study demonstrates that ICT workshops would boost VET teachers' confidence and competence in using technology effectively. Shilongo asserted that funding for VET often fell short compared to other educational priorities. He proposed that the government allocate funding for VET teachers to participate in exchange programmes, enabling them to learn from established VET systems, particularly in developing nations. These programmes would facilitate the exchange of ideas and teaching methods among VET teachers from different countries. In addition, participation in VET exchange programmes would serve as professional development that could motivate VET teachers to attain further skills and qualifications, opening opportunities for career advancement. Shilongo explained:

I have seen that institutions of higher learning enter into agreements and partnerships with international universities, allowing them to exchange students to learn best practices. I would be proud if this could be explored for the TVET, which is more technical and involves practical activities. The need is even more critical now that TVET faces technology infusion so that students can see how technologically advanced other TVET institutions are in the region or beyond and what they can learn from them.

This quote highlights Shilongo's view that TVET institutions could gain from forming international partnerships and student exchange programs, much like those in higher education. This approach would give students the chance to learn from best practices and maintain competitiveness in an era of growing technology integration.

Furthermore, Shilongo noticed that TVET institutions needed diverse educational technologies and resources that facilitate interactive and engaging learning experiences, such as software applications, digital content libraries, online learning platforms, and hardware devices tailored to various subject areas and teaching contexts. He emphasised that the VET partner with the private sector to acquire educational and technological tools and resources.

5.3.5.1.5 Future plans for Shilongo's technology integration in VET teaching

This section highlights Shilongo's plans and how he envisioned continuing to integrate technology into his classrooms.

Shilongo believed that he still had a long way to go teaching in TVET and did not think of leaving the industry any time soon. He planned to apply his deep understanding of TPACK in his practice. Despite challenges accompanying technology integration, Shilongo was optimistic

and anticipated teaching with technology in the future because technology advances daily and he believed developing countries such as Namibia should be on the same level as world trends.

Shilongo acknowledged that he still needed further training, especially professional development programmes, to prepare him to understand TPACK thoroughly. He considered teaching with technology the best way to make his students understand the complex concepts in auto mechanics. He acknowledged that the future was promising with the introduction of electric vehicles, which may change the TVET curriculum a bit and become more technologically advanced than now. Shilongo expressed this as follows:

I have read in printed media that as global awareness of climate change and the need for cleaner energy sources intensifies, Namibia is beginning to embrace electric vehicles as a viable alternative to traditional internal combustion engine vehicles. This transition is driven by several factors, including the country's renewable energy potential, government initiatives, and the broader global shift towards greener technologies.

Shilongo shared an email content that was circulated to all VET centres regarding Namibia's government plans. Shared here is part of the email (15 October), 2023:

In preparation for the COP26 summit the Namibian government committed itself to increase the number of electric vehicles (EVs) in the country as a method to reduce air pollution and greenhouse gas emissions.

There are currently about 100EVs in Namibia, with an initial goal of 10,000EVs by 2030 which was later increased to 96,500 by 2025. On the other hand, Namibia currently has about 400,000 combustion vehicles.

Shilongo explained that the email above was evidence that technology is the future, and TVET should adapt and embrace it so that Namibia is on the same page with global leaders: *“It's time to update the TVET curriculum to include training on both electric and combustion vehicles, preparing students to work with both during internships and in the industry”*.

Shilongo believed that revising the TVET curriculum on auto mechanics and mechatronics would enable the repair and service industry to align with the global trends in electric vehicle manufacturing and be relevant in providing their services.

As part of his plan, Shilongo will continue to enhance his knowledge and aims to integrate advanced technologies, particularly Artificial Intelligence applications tailored for the automotive industry. He said this would enable him to learn how Artificial Intelligence transforms areas like diagnostics, predictive maintenance, autonomous vehicles, and customer service. Shilongo narrated thus:

Once the theoretical knowledge is combined with practical skills, I think such courses would enable me as an auto mechanics TVET teacher to leverage Artificial Intelligence tools and technologies in my daily work.

The quote highlights Shilongo's belief that combining theoretical knowledge with practical skills is key to integrating AI tools into their teaching, ultimately enhancing both the learning process and teaching methods in auto mechanics.

5.3.5.1.6 Summary of Shilongo's case study

Shilongo was keen to bridge his practical expertise with modern advancements in automotive technology. As a tech-savvy VET teacher, he aims to leverage cutting-edge tools and digital resources to enhance his students' learning experiences. His unique blend of hands-on experience and a contemporary teaching approach make him a valuable resource for students aspiring to excel in automotive mechanics. His commitment to staying abreast of technological developments in the automotive industry reflects his dedication to providing a comprehensive and forward-thinking education that prepares students for success in the dynamic and evolving world of auto mechanics.

Shilongo employs diverse technologies in his classroom to offer students learning opportunities, assessments, and instructional support. He recognises that student knowledge comes from various sources, and technology plays a crucial role. Shilongo emphasised that technology is not a standalone element for him; instead, he can combine it with numerous content and pedagogical aspects. As a result, he possesses well-developed TK and adeptly employs various techniques to achieve a broad range of educational objectives, from fostering abstract thinking to addressing real-life problems.

In his classroom, Shilongo uses personal computers, the LMS, those provided by the institution, and those owned by his students, such as the set of squares and mobile phones.

5.3.5.2 Ndangi's case study

Ndangi (pseudonym) was an average-height man between the ages of 30 and 35. Ndangi was an Otjiherero-speaking man from the Omaheke region in central Namibia. During the semi-structured interview, Ndangi revealed that he grew up in a rural community where traditional livelihoods were deeply rooted in agriculture, especially livestock farming. Most of Ndangi's family members did not have formal education and depended on livestock farming for survival.

Further, the family faced economic hardships due to fluctuations in agricultural yields and limited market access. In this rural community, Ndangi was not exposed or had access to technology. Despite limited exposure to modern technology, Ndangi recognised the potential of technology to address socioeconomic challenges in his community and demonstrated a keen interest in sustainable technologies and renewable energies, especially those that would transform the agricultural practices in his rural community. Leveraging local resources and collaborative partnerships, Ndangi initiated projects to promote sustainable development and economic resilience, ultimately revitalising his community's economy. So, through self-initiated learning and community engagement, Ndangi explored innovations such as solar energy-powered irrigation systems and eco-friendly building materials.

- **Ndangi's TVET Career**

Ndangi has three years of teaching experience as a TVET teacher for horticulture and crop production. Informed by his upbringing, Ndangi has a great passion for agriculture and believes in food security and self-reliance. Ndangi holds a diploma in agriculture from the University of Namibia-Ogongo Agricultural Campus, where he specialised in horticulture and crop production. Extensive practical experience gained through years of working in various agricultural industry sectors, ranging from commercial farming to research and development, has complemented Ndangi's achievements.

Motivated by a passion for sharing knowledge, Ndangi transitioned to vocational education, where he could impart his knowledge to aspiring students in agriculture, particularly horticulture and crop production. He began his teaching career at Nashikaku VET institution, where he developed and implemented horticulture and crop production courses aligned with industry standards. But before transitioning to teaching in VET as a VET teacher, Ndangi worked as an agricultural extension officer at the Ministry of Agriculture in the Omusati region. His responsibilities included bridging the gap between the Ministry of Agriculture and rural farmers by providing them with valuable information, resources, and support, including conducting training sessions, workshops, and demonstrations to help farmers adopt modern and more efficient farming techniques. This practical experience gave him valuable insights into the real-world applications of horticultural principles.

During the semi-structured interview, Ndangi admitted that he recognised the dynamic nature of the agricultural sector and consistently attended conferences, workshops, and training sessions to stay current with the latest advancements in horticulture, crop science, and

agricultural technology. This commitment to ongoing learning allowed him to enrich his curriculum with up-to-date content, ensuring that students received a comprehensive and relevant education.

Ndangi's academic and professional background and exceptional teaching methodologies, which he self-initiated learned when he started teaching, led to his success as a TVET teacher. He also attended various workshops and training, which equipped him with pedagogical practices relevant to his courses. He employed a student-centred approach, combining traditional lectures with hands-on activities, field trips, and collaborative projects. Ndangi believed in the importance of fostering critical thinking and problem-solving skills in his students, preparing them for the challenges they would encounter in the diverse field of horticulture.

His dedication extended beyond the classroom as he actively engaged with industry professionals, local farmers, and agricultural organisations to establish partnerships that provide students with valuable networking opportunities and real-world insights. Ndangi's engagements included forging opportunities for students to undertake internships or apprenticeships during their studies and eventually securing employment. His commitment to the success of his students was evident in the high level of support and mentorship he provided, guiding them towards academic excellence and future careers in horticulture and crop production.

With Ndangi at the helm, the VET programme in horticulture and crop production thrives, producing graduates who are well-versed in theoretical concepts and equipped with the practical skills and industry knowledge needed to make a meaningful impact in the agricultural landscape.

When asked during the semi-structured interview to describe his typical day, Ndangi stated that his typical day followed a set timetable for when he was conducting his lessons. When Ndangi has a free period, he got busy planning for the following day and preparing assessment activities for his students. Ndangi also did administrative work for his courses, such as recording students' work and filing documents.

Ndangi was very outspoken and student oriented. He enjoyed working with students and helping them when needed. Growing up, Ndangi focused on livestock farming, which is one of the traditions and culture of the Ovaherero tribe. The Ovaherero tribe's culture makes them dependent on buying mealie meals and other products produced in different parts of the

country. However, he was happy to have diverted into teaching agriculture courses, enabling him to diversify his career and personal life. He narrated that agricultural knowledge allowed his students to learn food production processes for their own consumption and selling purposes to earn an income. He indicated that students could kick-start independently and become entrepreneurs after completing their programme.

5.3.5.2.1 The individual understanding and shifting of TPACK understanding

One of the questions in the questionnaire was for Ndangi to select the definition that best described his understanding of TPACK. He selected c) (See Table 5.).

Ndangi could not select the definition related to his understanding of TPACK, as indicated in Table 5.3. He understood it as c) a model to describe the knowledge requirements for TVET teachers to integrate technology into teaching. This description did not include the subject matter/content and did not reflect his awareness of TPACK as knowledge for incorporating technology in teaching and content. During the semi-structured interview, Ndangi revealed that he had never come across or encountered such an acronym before.

It is my first time seeing and hearing the word “TPACK”. (Laughing) The funny thing is that I knew about technology, pedagogy, and content but did not know one could abbreviate it as TPACK. Sometimes, we think we do not know something when it is just under our noses, which is the same with TPACK.

From the quote above, the study emphasises that there was enough evidence that Ndangi knew and understood technology, pedagogy, and content despite a lack of knowledge about the TPACK abbreviation. However, the study indicates that the limited knowledge about TPACK could be because TPACK is a new concept, especially in the VET context. Another reason could be that Ndangi might not have heard about TPACK before because not much research has been done on VET in Namibia despite the technological training he attended in 2021. He, however, admitted that one must have the skills to use technology, know the subject matter, and apply suitable teaching methods to teach effectively. Further, the study emphasises that having TPACK is of tantamount importance to realising effective teaching and understanding of subject matter by students.

Ndangi acknowledged that he needed to learn and understand TPACK to use and integrate technology into his classrooms. The study highlights that understanding TPACK would encourage him to develop effective teaching strategies, including identifying the most suitable pedagogical approaches for a given topic while leveraging technology to support and enhance

those strategies. He also admitted that once his understanding of TPACK takes shape, he would be able to balance technologies and teaching content to support student learning. He narrated during the interview:

Most of my students lack the motivation to pursue agricultural courses further. Hence, enhancing my TPACK understanding would help me strengthen student engagement and motivation to stay on the course.

The quote above shows how dedicated Ndangi is in his teaching as he identifies low student motivation in agricultural courses as a challenge and believes that enhancing his TPACK knowledge will help make lessons more engaging, ultimately increasing student motivation to continue the course.

During the semi-structured interview, Ndangi was asked to place a tick (✓) on the TPACK diagram to indicate his TPACK. Figure 5.4 shows an extract of the question from the semi-structured interview schedule.

Ndangi placed a tick on CK only and revealed that:

My TPACK would mostly be on CK, which is my most critical point. My college years and life farming experience prepared me adequately. I am a recent graduate with a bachelor's degree in agriculture from the University of Namibia -Ogongo Campus and do not possess any other qualifications. So, I only have the content knowledge and a little technological expertise, which I self-initiated and learned when I started my teaching career.

This quote highlights Ndangi's awareness that his expertise is primarily in Content Knowledge (CK), which is crucial for their teaching, acknowledging the need to enhance his technological and pedagogical skills.

Nevertheless, Ndangi admitted that he possessed some PK:

I can teach my students because I can perfectly well relate to when I was a student, so I use the same methodologies and technological knowledge of regular technology operations, such as using my Android phone and working on a PC, but that does not translate into knowing how to integrate technology in teaching.

This quote highlights Ndangi's awareness that while he can relate to students and use basic technology such as phones and PCs, this doesn't necessarily mean he knows how to integrate technology into their teaching.

When asked about his view on the "T" position in TPACK concerning vocational training disciplines, Ndangi indicated that technology had been making waves, and he welcomed and

appreciated its presence in VET. Despite his limited TK among and inadequate technological resources, there was a positive atmosphere and attitude towards using technology in teaching in VET. Ndangi believed that he needs to be trained to teach with technology during pre-service training. He further posited that it would be helpful if he could acquire the TPCK in the same order as they appear in TPACK as he expressed during the interview:

Mhhmmm!! I have been aware of technology but did not know it would impact teaching and learning. Things could have been different by now if I had acquired technological knowledge first and been able to link the three (technology, pedagogy, and content) together.

Ndangi reflects above on how, despite being aware of technology, he did not initially understand its significance for teaching and learning. He recognises that his teaching could have been more effective if he had first gained technological knowledge and integrated it with pedagogy and content, viewing this as a missed opportunity for improvement.

So, during the semi-structured interview, I asked Ndangi how he used technology in teaching, explicitly integrating technology into his teaching. For instance, Ndangi explained that he used the available technologies to disseminate agricultural content. On this point, during the interview, he said:

Technology enables me to see what I could not see before, as I could use the computer to search for information and present the subject content to my students. Technology has opened my eyes and has made my teaching easier and simpler.

This quote indicates that Ndangi acknowledges that technology has improved his ability to access information and present content more effectively, simplifying the teaching process and offering new perspectives that enhance their approach.

Similarly, I asked Ndangi the reasons for using technology. He admitted to using technology sometimes in his lessons to have students work collaboratively and prepare educational materials. He explained that VET had limited well-developed teaching and learning materials, specifically in his discipline, because it was recently introduced and added to the VET programme. He stated:

I must develop my content to teach following the VET curriculum as a guide. I sometimes even use secondary school materials to supplement my own to have enough content to teach.

It is evident from the quotation above that Ndangi does not sit idle waiting to use what is provided in the teaching guides but goes out of his way to find alternative strategies to supplement the available content for his course. The alternative strategy includes searching for information relevant to his course via the internet and other available sources which he can access. However, Ndangi acknowledged that he had limited access to the internet at the Nashikaku VET institution as it is in a remote area with poor internet service and a mobile network. So, Ndangi explained:

Nashikaku VET institution is new; we are still growing. The demand for VET education is growing, but we need to conduct proper marketing and awareness for it to be known. As time passes, we will be able to acquire most of the services and infrastructure necessary for effective teaching and learning.

In the quote above, Ndangi reflects on Nashikaku VET institution's growth and the rising demand for vocational education. He recognises the need for better marketing and awareness to promote the institution and express hope that, over time, the required services and infrastructure will be obtained to enhance teaching and learning.

Furthermore, Ndangi mentioned that despite limited access to the internet at the institution, he still used online services such as email, the school website, YouTube, and online educational websites to research information and incorporate technology into his teaching. He reminisced:

Yes, I use my gadgets when I have full network coverage far from the institution. So, I can still access all online services listed above from my own space and at my own pace. I can obtain information to supplement the teaching and learning materials through that.

The quote above clearly shows that Ndangi's use of technology extends beyond the institution. He uses his personal technologies to access online resources in areas with reliable network coverage, allowing him to work at his own pace and supplement the resources provided by the institution.

The questionnaire included a question for the participants to self-report on their TPACK. When asked to self-report his TPACK and technology integration in VET, Ndangi expressed his TPACK proficiency by responding to Likert-type scale items, assigning values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

Ndangi disagreed on most aspects related to TK compared to other TPACK constructs. He indicated he could use technology and knew less about which technology suited his teaching. However, he strongly disagreed that he could learn new technology quickly, play around with

the technology, and have the technical skills to use various technologies. The study highlights that the finding aligns well with placing his TPACK on CK only as it shows that he had limited TK despite less knowledge of using standard and essential technologies such as Microsoft Word and mobile phones in his teaching. Furthermore, Ndangi self-reported agreeing with the aspects of CK in terms of being familiar with the subject content as prescribed by the VET curriculum, having sufficient subject knowledge for all his VET trades, and being familiar with the teaching and learning materials specified for the VET discipline and level of trade. The study demonstrates good self-reporting as it reflected and supported his strong point on CK, which was acquired during pre-service training, as reported in the previous section.

He stated:

My strength lies in CK because that is the knowledge I have acquired from my pre-service training as an agricultural student. CK was necessary at that time so that I understood my work better.

The quote reveals that Ndangi is competent in CK due to the training he underwent before formally starting his career as an agricultural student. This suggests that a strong grasp of subject-specific knowledge was essential during their pre-service training, enabling him to comprehend the work more effectively.

This shows that Ndangi also agreed with aspects of PK, such as knowing how to change his teaching styles to suit theoretical and practical lessons. He argued that his PK developed due to the three teacher development training sessions he attended, which could also be linked to his experience as an undergraduate student at the University of Namibia. Moreover, Ndangi admitted that his limited TK had forced him to self-learn and acquire knowledge and expertise to use and integrate technology into teaching. Ndangi stated:

I acknowledge my limited technological knowledge; unfortunately, I cannot be like that forever. So, I had to find strategies for acquiring PK and TK, especially when I decided to join TVET as a teacher. I self-learned and taught myself to possess technological and pedagogical knowledge.

This quote reflects Ndangi's initial lack of technological knowledge but was determined to improve. Realizing the need for growth, he took the initiative to develop both PK and TK, particularly after becoming a TVET teacher. Through self-learning, he enhanced his skills, showcasing adaptability and dedication to professional development.

Thanks to self-initiated learning on TCK aspects, Ndangi agreed he knew a few technologies he used to present the subject content better, learnt how to use specific technologies to teach specific VET trade concepts/topics and chose technologies that made it easy for students to understand VET concepts. Moreover, on TPK, Ndangi agreed to have the ability to use technology that promoted pedagogical approaches in his lessons, so Ndangi expressed:

The self-initiated learning strategies I undertook to learn sharpened and enhanced my limited technological knowledge and enabled me to use and integrate technology into lessons. Self-initiated learning also taught me to select pedagogical practices that fit the content and technological tools.

The quote emphasises how self-initiated learning enhanced Ndangi's technological skills and allowed him to incorporate technology into lessons. It also helped him identify appropriate pedagogical strategies that effectively align with both content and technological tools.

Ndangi acknowledged that after probing and thorough discussion during the semi-structured interview and FGD, his view and understanding of TPACK changed. That understanding influenced his self-reporting on TPACK aspects, agreeing that he could select technologies that strengthened his subject content, pedagogies, and student understanding and share his TPACK with other TVET teachers while choosing topics that combined the knowledge domains.

When I asked during the semi-structured interview about his motive to use technology, Ndangi narrated that the education set-up had changed entirely, and the traditional ways of teaching, which were believed to yield the required competencies and understanding, no longer did so.

So, he stated:

Today's education requires students to be hands-on with activities. It is no longer teacher-centred but has transformed into a student-centred approach in which students play a significant role in their learning. I found technologies to close this gap as they make teaching easy and quick for students to understand concepts. Technology use has also taken shape, and as a VET teacher, I expect to be able to integrate technology into my teaching.

From the above quote, it is clear that Ndangi recognises the transition from a teacher-centered to a student-centered learning approach, highlighting the value of hands-on activities. He views technology as a key tool in facilitating this shift, enhancing teaching effectiveness and improving students' understanding of concepts.

Since Ndangi taught horticulture and crop production, I noted during classroom observation that he used most of the technologies he could access for agricultural purposes as the subject involved practical fieldwork/activities such as spades, hoes, and rakes. These technologies

were displayed in the classroom for demonstration during teaching and when they had practical lessons in the school garden. There was, however, a whiteboard in the classroom that Ndangi could use to make notes. This, Ndangi stated during the interview, was because the institution opened in 2020 and had not acquired the necessary digital technologies for teaching and learning agriculture courses.

Regarding how he integrated digital technology into teaching, Ndangi stated there were fewer technologies to incorporate in teaching due to poor and limited internet and technological infrastructure access. In addition, most students Ndangi taught resided in rural communities with low socioeconomic activities, leading to most of them not having access to or owning essential technologies such as smartphones and laptops. Ndangi used his laptop to participate in technology-integrated lessons. He postulated:

This institution is new and has yet to acquire many of the technologies that can be used in teaching. As a growing institution, more resources are needed before we can plan what to invest in.

The quote highlights Ndangi's acknowledgement that the institution is still developing and currently lacks essential technologies for teaching. However, he highlights the need for additional resources to support its growth and stress the importance of careful planning before investing in technology.

Moreover, I noted how Ndangi started his lesson during the classroom observation. He recapped the previous day's work and distributed the students' printed notes for the lesson. Figure 5.8 depicts one of the lesson plans Ndangi used for his lesson.

Name of Trainer:	
Venue:	
Duration:	2 hours
Date:	19 January 2024
Occupation Area/Subject:	Horticulture and Crop Husbandry
Level:	2
Unit ID:	1298
Unit Title/ Topic:	Conduct basic gardening, nursery and ornamental plant techniques and operations
Element:	1
Lesson Objectives	
By the end of this topic the trainees will be able to:	
1. Describe the economic contribution of ornamentals gardening and ornamentals and nursery production in Namibia. 2. Recall the uses of ornamental plants. 3. Recall the types of ornamental plants. 4. Explain the social contribution of ornamentals plants.	
Any special need to be addressed.	
Teaching Aids/Resources	
- Unit standard - Trainee guide - Projector - Computer	
Introduction	
Element 1. Demonstrate knowledge of use of ornamental plants, ornamentals gardening and ornamentals and nursery production	
Entry requirements: The Trainer ask about prior- <u>knowledge</u>	
The trainer explains the objectives to trainees	
Lesson Development / lesson presentation	
Introduction 1.1 Introduce the <u>topic</u> 1.2 Explain the learning <u>outcomes</u> 1.3 Test for prior knowledge: Trainees to explain in their own understanding what ornamental plants are. 2. Explain the uses of ornamental plants. 3. List and explain the types of ornamental plants. 4. Explain how ornamental plants contribute to the country's <u>economy</u> 5. Conclusion: ask trainee to recap on the main points.	Trainees activities - Trainees to listen attentively - Trainees to answer the questions - Trainees to take note

Figure 5.7: Ndangi's lesson plan

Figure 5.8 shows that Ndangi's lesson plan indicated the day's topic: to teach basic gardening, nursery, and ornamental plant techniques and operations. In the lesson plan, he highlighted the learning objectives and teaching aids/resources, such as the projector and computer.

During the semi-structured interview, I asked Ndangi how technology had assisted him in designing assessment tools such as question papers and worksheets. Ndangi narrated that

technology was helpful as he used his laptop to create most of his class activities, projects, and question papers. He expressed:

I sometimes have no idea about the type of questions or projects I should give the students, so I Google them, and various samples, designs, and formats pop up. I can state that I set my question papers or projects as per international standards.

The quote indicate that Ndangi acknowledges difficulties in deciding on suitable questions or projects for students and relies on Google to find various examples and formats.

When asked how VET's ICT workshops changed the pedagogical practices he used to teach, Ndangi stated that he was proud to have been part of the workshop as it changed his pedagogical practices. He revealed:

Agriculture is a practical subject, so most topics taught should be accompanied by practical work and demonstration. When I was teaching the soil composition topic, I just read to the students what was explained in the handout. However, after the technology workshop, although I did not have to use technology to teach the same topic, I had to bring in containers of the different types of soil and water to demonstrate to students which one was more suitable for which crops and why. These pedagogical practices made students understand the topic better as they could relate by looking at the soil as the same, even if they were working on it at home.

Ndangi explained that it was due to the pedagogical practices, as illustrated in the quote above, that students were more involved in the teaching and learning as they had to pour water into the container and explain what was happening to the soil, including the reasons behind the change. Furthermore, Ndangi narrated that those practices induced more interactions between him and the students. Interestingly, the interactions were clear and engaging, as I observed during the non-participatory classroom observation. Therefore, Ndangi postulated:

Practical activities encourage hands-on learning, where students actively engage with the material, making lessons more dynamic and interactive. Hence, a video demonstrating a particular practical activity helps students connect theoretical knowledge to practical applications, deepening their understanding of the subject matter.

The quote above emphasises the value of practical activities and videos in enhancing hands-on learning, helping students connect theory to real-world applications and deepening their understanding.

Furthermore, Ndangi explained:

It is easy to explain a topic using a video demonstrating how tools such as rakes, hoes, and spades can be used in practical agriculture lessons and measuring tape for measurement to ensure consistency in the distance between plants.

The quote underscores Ndangi's appreciation for using videos to illustrate practical agricultural concepts. Videos are more clear and easy for students to understand concepts than traditional teaching.

Ndangi also postulated that explaining a topic using various technologies for the demonstration was done with the students while being hands-on so that they learned how to do it in the absence of a TVET teacher. During one of their practical lessons, I also observed that most students from the local area of the TVET institution were more knowledgeable about using technologies such as hoes and spades for practical activities. Ndangi stated this was because they illustrated to him how to hold the tools and from which angle during the practical and hands-on lessons.

5.3.5.2.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Ndangi explained that he had completed an undergraduate diploma in agriculture from the University of Namibia- Ogongo campus, which enabled him to become a TVET teacher for horticulture and crop production. Evidence from the classroom observation revealed how he interacted with students on the subject content and the various instructional designs he used within two hours. He moved between theory in the teaching guides, demonstrating on the board and ensuring students understood the concepts. On the day of classroom observation, Ndangi taught vertical farming, which made sense as he showed the problems of urbanisation and land scarcity within the constrained space of his classroom. The study demonstrates that having CK is also a source of innovation in teaching because it enhances a person's ability to connect ideas and patterns and analyse and solve problems within that environment. So, he narrated:

It is incredibly fulfilling when a teacher possesses adequate subject knowledge. I believe that knowing my subject allows me to be creative with the content and find innovative ways to deliver it in the classroom.

The quote expresses Ndangi's view that a solid understanding of the subject is crucial for effective teaching. With strong subject knowledge, he feels confident in using creativity and innovation to present lessons, ultimately improving the learning experience and making it more engaging for students.

Ndangi also emphasised during the semi-structured interview that he acquired his PK and TK from the technological workshops he attended, and he self-learned the rest by engaging with various online platforms such as YouTube videos via his laptop and phone. Furthermore, he

engaged fellow TVET teachers who had undergone formal training, including PK, for best practices and ideas on teaching using technology. Therefore, the study reveals that there is a tone set for collaboration and information sharing among fellow TVET teachers. The study also argues that ICT workshops are part of professional development to enhance knowledge. Ndangi explained that:

I didn't rely on just one source for my PK and TK, as it may not have been effective. Instead, I used multiple sources to determine which ones were more effective and where I could gain the most knowledge.

The quote highlights the Ndangi's proactive approach to improving his TPK by exploring multiple resources, rather than relying on a single source, to gain a well-rounded understanding and enhance their teaching effectiveness.

Ndangi further highlighted that CK was his solid knowledge base. Hence, he also focused on self-initiated learning to integrate technology to upgrade and improve his understanding of the content in alignment with current student needs. Ndangi explained that self-learning allowed him to balance what he acquired during training and what the curriculum expected. The study argues that due to changes in the curriculum to accommodate market trends and student demands in technologically enhanced environments, it is also fit for TVET teachers to self-learn to improve and update their knowledge bases.

I enjoyed self-initiated learning because it allowed me to learn at my own pace. This flexibility enabled me to review concepts as many times as needed until I fully grasped them. I also learned to be self-discipline and patient during the process.

The quote highlights Ndangi's positive experience with self-initiated learning, which allowed him to learn at his pace and revisit concepts until fully understood. This process not only enhanced his understanding but also developed self-discipline and patience, emphasising personal growth and the control over their learning process.

However, Ndangi felt challenged to balance technology, pedagogy, and content despite technological skills and know-how, which contributed to how he integrated technology into teaching. The study argues that if Ndangi knew how to interact between the three knowledge domains (technology, pedagogy, and content) and had access to technological infrastructure and internet services at Nashikaku, his teaching experience would significantly enhance his ability to integrate technology into the educational process effectively.

5.3.5.2.3 Drivers and constraints for integrating and use of technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

During the semi-structured interview, Ndangi was asked to describe the self-initiated learning activities he engaged in that might have helped him integrate technology into teaching, Ndangi revealed that he used his laptop to watch “Do It Yourself” (DIY) videos for projects in agriculture these taught him the more advanced procedures and processes to grow, care, and handle crops. He stated, *“DIY videos for projects in agriculture teach me the “how to do-it-myself” techniques, which I pass on to students in the classroom”*. The study emphasises various other means of learning that TVET teachers could explore and undertake to understand what they could not learn through formal training. Ndangi highlighted that DIY made it easy for students to understand the topic as the guidelines and processes were more transparent and straightforward than the teaching guides. The study notes that self-initiated learning of some technologies has helped TVET teachers find ways to integrate technology into their classrooms. For example, Ndangi narrated:

I watched documentaries on TV and educational videos on YouTube to learn more about agricultural practices and the use of technological tools to speed up food production.

The quote highlights Ndangi’s proactive approach to enhancing his knowledge by using resources like documentaries and educational YouTube videos. This demonstrates his effort to stay informed about agricultural practices and the role of technology in food production, ultimately improving their teaching.

Furthermore, Ndangi ensured good relationships with fellow TVET teachers to obtain assistance in content, pedagogy, and technological advice. The relationships between himself and fellow TVET teachers allowed him to engage them in learning the best practices for using technology and create an interaction between technology, pedagogy, and content. He explained:

I remember struggling to get a diagram for conservation tillage as a soil conservation practice from a PDF document to show and demonstrate to students the following day. It took me almost two hours to cut or copy the diagram, but I could not. I decided to call one of the lecturers from UNAM, where I received pre-service training. It was unbelievable; he directed me and said, open the diagram page on the pdf document, go to start on your laptop, type in “snipping tool”,

click on it, highlight the part you would like to copy, then save. I was astonished as it came out exactly as I wanted it to, and then boom, I learned how to do it.

The quote illustrates Ndangi's frustration with a technical task and their resourcefulness in seeking help from a lecturer. The lecturer taught him how to use the "snipping tool" to extract a diagram, leading to a moment of realisation and new learning. This experience highlights the importance of problem-solving, seeking guidance, and learning from others to overcome challenges and acquire new skills.

The study indicates that, for Ndangi, self-initiated learning fostered a sense of personal responsibility for their professional development. Ndangi undertake self-initiated learning independently navigating digital resources, using online tools and engaging with educational platforms, promoting autonomy and cultivating digital literacy. From Ndangi's narrative, one can deduce the collaboration and information-sharing scenario as the lecturer from UNAM gave him instructions on how to get the diagram from the PDF document. However, Ndangi disappointingly stated that it was not easy to self-initiate learn educational-related technologies. He mentioned:

Sometimes, I am faced with an information overload and get confused about what to take and which to leave. It also takes too much time to go through online sources before getting what you are looking for, which demotivates me from continuing. So many distractions also prolonged the time I faced, like technical issues such as internet connection interruption and noise level from nearby shebeens as I rent a room where most residents have established shebeens to make a living, making it challenging to maintain focus.

The quote above reflects how Ndangi describes the struggles he faces with information overload, making it hard to sift through online sources to find relevant information, which leads to frustration. He also mention external distractions like internet issues and noise from nearby shebeens, which affect his ability to focus and remain motivated. These challenges highlight how both personal and environmental factors can disrupt the teaching and learning process.

Nevertheless, as one of the SDL theory's principles, Ndangi underlined that self-initiated learning required patience and constant motivation. Ndangi argues that despite the challenges, he stayed on course and pushed through the limits as he knew what he wanted to achieve in the first place. The study highlights that Ndangi seemed well prepared to self-learn technologies as he proved that his abilities and skills influenced him to persevere despite the odds.

Moreover, Ndangi believed that technology integration in his classroom improved his pedagogical approaches; however, it required the availability of technological infrastructure.

He stated he looked forward to learning to use modern Artificial Intelligence to support his students' understanding of concepts and virtual farming experiences.

5.3.5.2.4 Harmonising the support that initiates self-TPACK development

This section outlines the support Ndangi perceived as beneficial for incorporating technology into his teaching practices. When asked during the semi-structured interview about the support he requires to incorporate technology into teaching, Ndangi believed that professional development programmes would assist TVET teachers in learning how to integrate technology into teaching. Therefore, he suggested that the Ministry of Higher Education, Training, and Innovation (MHETI) and the NTA should always organise workshops and training for specific subject areas. He stated:

I believe teachers always need refresher training, workshops, or seminars to stay updated with current knowledge. It would be beneficial if these training sessions, workshops, or seminars were organized or facilitated by higher authorities, such as the ministry.

Ndangi's statement above highlights the need for ongoing professional development for teachers through refresher courses, workshops, or seminars to keep up with the latest knowledge and teaching strategies. He reminisces that it would be more impactful if these initiatives were arranged or supported by higher authorities, like the ministry, to ensure they are accessible and meaningful.

This study argues that as authorities and policy developers, MHETI and NTA could align their actions with the policies they are responsible for implementing. However, Ndangi as one of the TVET teachers who implemented the policies could only integrate technology once he was well-equipped and resourced with technological infrastructure.

Ndangi further indicated that the VET institutions should have the latest technological infrastructure to make online courses and webinars easier, allowing them to explore advanced topics and emerging technologies that cater to students with diverse learning needs and styles. For example, he stated:

I need more information on climate change and how it would impact farming practices. This information is current, and I can only obtain it once I have access to unlimited internet service provided by the institution. I also do not have enough money to buy data when searching for information.

The above quote highlights Ndangi's difficulty in obtaining information about climate change and its effects on farming due to limited access to internet services at the institution and financial constraints preventing them from purchasing data. This reflects the barriers that can impede access to essential educational resources, hindering both personal development and the quality of teaching.

He added that the private sector, for whom the VET sector produced graduates, should provide support and assistance to ensure these graduates were well-trained and acquired the right skills for the job market. The study highlights that equipping graduates with 21st-century skills would enable them to meet the current job demands, which are technologically driven.

In addition, Ndangi emphasised encouraging some of his colleagues to establish a community of practice where they could share information, offer advice, and practice integrating technology in their classrooms. As a novice, Ndangi believed the platform would greatly assist him and fellow TVET teachers as it provided space to learn more about technology integration into teaching. He postulated:

I no longer believe in working in isolation. As educators, coming together to learn from one another, inspire each other, and teach with a unified voice is the way forward in today's world. I believe that collaborative platforms would be incredibly valuable and have a positive impact on the teaching practices of many educators.

In the above quote, Ndangi emphasises the significance of educators working together, sharing knowledge, and inspiring one another, rather than working in isolation. He believes that collaborative platforms can have a positive impact on teaching practices and improve the overall teaching experience for many educators.

Ndangi remarked that since agriculture was recently introduced in the TVET, it was only fit that best practices from TVET institutions that had been in the field for a long time could be sought. Therefore, Ndangi emphasises that the government assist the NTA in sending selected TVET teachers to other well-established TVETs that offered agriculture, specifically horticulture and crop production, to learn from and establish links and relationships for future engagements and cooperation. Ndangi narrated:

I prefer learning from those in the field for some time. It also equips you with strategies for moving things forward from your angle. Agriculture is the backbone of food production, and it is essential to realise self-reliance. And there are those specific nations that have been doing so well in that field. Namibia has indeed a lot to tap from other developed or developing countries.

This quote emphasises Ndangi's belief in the importance of learning from experienced individuals in the field, especially in agriculture, to gain practical knowledge and strategies. The teacher also acknowledges the significance of agriculture in ensuring food production and self-reliance, and highlights the potential for Namibia to benefit by learning from nations that have excelled in this area.

5.3.5.2.5 Future plans for Ndangi's technology integration into VET

This section presents Ndangi's aspirations for the future, envisioning a continued integration of technology within his classrooms.

Ndangi holds a distinct perspective and approach regarding digital technology. In contrast to other VET teachers who were content with the existing technology, Ndangi actively sought a balance between what was currently feasible and what innovations brought. He emphasised the importance of laptops and mobile phones, identifying them as a top priority for the coming years.

Regarding horticulture and crop production, Ndangi considers a paradigm shift in teaching sustainable practices that would reduce carbon emissions. Such practices include using advanced technologies and equipment requiring more space than traditional methods.

Ndangi plans to continue learning to enhance his understanding of TPACK and improve his pedagogical practices and subject matter. He postulated:

Agriculture is at the top of the government agenda as the country steers efforts to encourage and increase food production in a drive to achieve sustainable development goals, specifically SGD2. Thus, the introduction of agriculture as a course in TVET is to train and equip students with agricultural skills so that they can spearhead agricultural schemes throughout the country.

Therefore, continued learning would enable me to acquire top-of-the-range knowledge, skills, and expertise that are part of the government's green initiatives to undertake agricultural projects for food production in the country.

This quote illustrates Ndangi's recognition of the importance of agriculture in national development and the government's green initiatives. He sees the introduction of agricultural courses in TVET as an opportunity to equip students with the skills necessary for advancing agricultural projects, which will contribute to the country's sustainable development goals. Ndangi is committed to acquiring advanced knowledge and expertise in agriculture to support these initiatives.

5.3.5.2.6 Summary of Ndangi's case study

With four years of teaching experience, Ndangi's dedication to agriculture is evident in his strong belief in food security and self-reliance principles. Ndangi built on his educational foundation with a diploma in agriculture, which he earned from UNAM-Ogongo Agricultural Campus. He specialised in horticulture and crop production, gaining comprehensive farming knowledge and skills.

Regarding technology integration, Ndangi is committed to incorporating innovative tools and methods into his teaching approach. Recognising the pivotal role of technology in modern agricultural practices, he seeks to expose his students to cutting-edge advancements. His integration strategy involves using technology to enhance learning experiences, promote sustainable farming practices, and instil a sense of self-reliance among students.

Focusing on fostering food security, Ndangi leverages technology to provide students with hands-on experiences in horticulture and crop production. Through virtual simulations, online resources, or precision agriculture tools, he seeks to equip his students with the skills and knowledge necessary to succeed in the changing agricultural landscape.

Ndangi's integration efforts align with his vision of empowering the next generation of agriculturists. By blending traditional agricultural wisdom with contemporary technological advancements, he envisions creating a learning environment that prepares students for future challenges and cultivates a deep appreciation for agriculture's essential role in ensuring food security and sustainability.

5.3.5.3 Angula's case study

Angula is an Oshiwambo speaker who spent most of his childhood in northern Namibia, where he was born. Aged between 35-40 years, he grew up in a remote village in the Oshana region where access to modern technology was limited. During the semi-structured interview, Angula indicated a natural affinity for technology, often taking apart and reassembling old electronic devices found in the village and building wire cars from scrap materials that boys played within the village. Despite the lack of formal education in technology, Angul's innate curiosity and problem-solving skills led to innovative solutions using locally available materials. It is from these childhood practices that Angula's interest in automotive developed.

Angula's family struggled to make ends meet in the village, relying on subsistence farming to cultivate a land portion area not exceeding one hectare, suitable for small-scale entrepreneurial activities. The economic challenges faced by the family sparked Angula's entrepreneurial spirit and drive to create opportunities for financial empowerment. Therefore, leveraging his passion for technology, Angula started a small business repairing and repurposing electronic devices for the local community, providing valuable services while generating income for the family. Angula's determination to succeed in the technology industry remained unwavering despite the economic constraints, fuelling aspirations for broader economic transformation in his community.

Over the past decade, Angula has established himself as a seasoned and highly respected auto mechanics TVET teacher at an Evangelical Lutheran VET institution. With a strong foundation in automotive technology and a passion for teaching, Angula has become an integral part of the educational institution, shaping the next generation of auto mechanics.

Angula began with a solid educational background, including a National Trade Diploma in Automotive Engineering and a Diploma in TVET from the Namibia University of Science and Technology (NUST), followed by four years of practical experience in the automotive industry. Angula undertook the diploma in TVET to equip himself with the instructional competencies required for a career as a TVET teacher.

- **Angula's Transition from Auto Mechanic to VET Instructor: Gaining Industry Experience and Embracing Technology**

Before joining VET, Angula worked as an auto mechanic in various automotive industry garages. This employment provided him with opportunities to gain industry experience and better prepared him, positioning him to train auto mechanics needed by the economy. Angula gained valuable and enriching experience for professionals in this field, including extensive hands-on experience with various vehicles, components, and systems and working with diverse vehicle makes and models, exposing him to different technologies and engineering designs. Furthermore, Angula admitted to having worked alongside other professionals, such as service advisors and parts specialists, enhancing their ability to collaborate effectively, which is the skill he has carried into the VET classroom. Although he grew up in an environment with limited access to technology, Angula has been exposed to technology throughout his career because the automotive industry continuously evolves with technological advancements. Therefore, mechanics working in this field, including Angula, are exposed to cutting-edge

automotive technologies, including computerised diagnostics and electronic systems, making them professionals with solid expertise in modern technologies.

Joining the Evangelical Lutheran institution a decade ago, Angula brought real-world knowledge to the classroom. His commitment to staying current with industry trends is evident in his regular updates to the programme, incorporating the latest technologies, diagnostic tools, and repair techniques. However, since Angula could not attend some technology workshop due to his tight teaching schedule, he had to self-initiate learning ways of incorporating technology in his classrooms. Self-initiated learning helped and allowed him to gain knowledge of various technologies for teaching.

In the first few years of his tenure, Angula focused on establishing a solid foundation for students. He emphasises the importance of understanding the intricacies of internal combustion engines, vehicle systems, and diagnostic procedures. Practical learning is a critical component of Angula's teaching style, and he ensures that students have ample opportunities to apply theoretical and practical knowledge in a well-equipped auto workshop.

As the programme progressed, Angula introduced advanced topics such as electronic systems diagnostics, hybrid vehicle technology, and computerised engine control. His curriculum reflects the increasing complexity of modern vehicles, preparing students for the challenges they will face in the ever-evolving automotive industry. Due to the advanced topics, Angula saw an opportunity to change his pedagogical approaches by adding a technological component to his teaching skills that would enable him to teach effectively and make it easy for his students to understand auto mechanic concepts.

Angula is not only a skilled TVET teacher but also a mentor who takes a genuine interest in the success of his students. His approachable nature and open-door policy create a supportive learning environment where students feel comfortable seeking guidance. Angula encourages critical thinking and problem-solving skills, instilling in his students the ability to confidently approach complex automotive issues. Throughout his tenure, Angula has actively participated in some professional development opportunities, attending workshops, seminars, and industry conferences. This dedication to continuous learning has kept him at the forefront of auto mechanics education, allowing him to pass on the latest industry knowledge to his students.

5.3.5.3.1 The individual understanding and shifting of TPACK understanding

One of the questions in the questionnaire was for Angula to select the definition that best described his understanding of TPCK. Angula selected b) (See Table 5.).

Angula has limited knowledge of TPACK and does not understand it because when asked to select the definition best describing TPACK, he chose (b) stating TPACK to be what TVET teachers needed to know to integrate technology in teaching with a focus on TPACK as its domains. The definition he selected is not what TPACK means. However, during the semi-structured interview, Angula posits that knowledge of how technology relates to pedagogies and some content often assists his practices of integrating technology into teaching. Angula explained that he was unaware that he could abbreviate TPCK as TPACK and that TPACK was a framework. Therefore, there is an impression that Angula has never come across the TPACK concept and acronym before, or it could be that since TPACK is a new concept and a form of knowledge to developing nations such as Namibia, the VET sector is not yet on par with other streams of education such as primary, secondary, and high education (universities). The study argues that some TVET teachers are not exposed to TPACK and do not understand its practical linkage to their practices.

During the interview, Angula stated:

Thanks to the WhatsApp group created for offsite communication and debate on my trade teaching, pedagogies, and subject matter. I have used technology in my classrooms. The WhatsApp group enables fellow instructors and me to share information on teaching strategies and any other issues of concern in the industry.

From the above quote, Angula sees the WhatsApp group as an effective tool for offsite communication and collaboration, allowing for the exchange of teaching strategies and addressing concerns within the industry. He appreciates how it enhances his ability to engage with colleagues and improve their classroom practices through technology.

Angula admitted that although he underwent the pre-service training, he still did not fully understand the TPACK concept despite integrating technology into teaching. He further stated that the probing and discussions during the study improved his understanding of TPACK, and he explained:

Through probing and discussions with you (the researcher), I gained knowledge of technological pedagogical content, which changed my pedagogical practices. The TPACK understanding allowed me to use technology to prepare my lessons so that I know well that they would require technology.

In the above quote, Angula acknowledges that his conversations with the researcher helped him gain a deeper understanding of TPACK. This knowledge influenced a shift in his teaching approach, prompting him to more consciously integrate technology into his lesson planning. He now appreciate how incorporating technology is crucial for improving teaching and ensuring it aligns with the subject matter.

Angula, however, acknowledged that most of the electrical tools used primarily for practical demonstration are also classified as technology and do not sometimes require additional digital technologies to explain them further. For instance, he mentioned:

Technology integration is needed for other topics, such as Engine Diagnostics and Troubleshooting because it involves using advanced tools and technology to identify and fix issues with a vehicle's engine. This topic requires software and tools to read error codes, provide live data, and help diagnose problems efficiently. Therefore, using such software and tools enhances students' understanding of the topic and prepares them to practice it.

The above quote highlights Angula's need for technology integration in subjects like Engine Diagnostics and Troubleshooting, as these areas depend on advanced tools and software for diagnosing and fixing engine issues. Including these technologies in the curriculum strengthens students' grasp of the topic and prepares him with the hands-on skills required for practical, real-world applications.

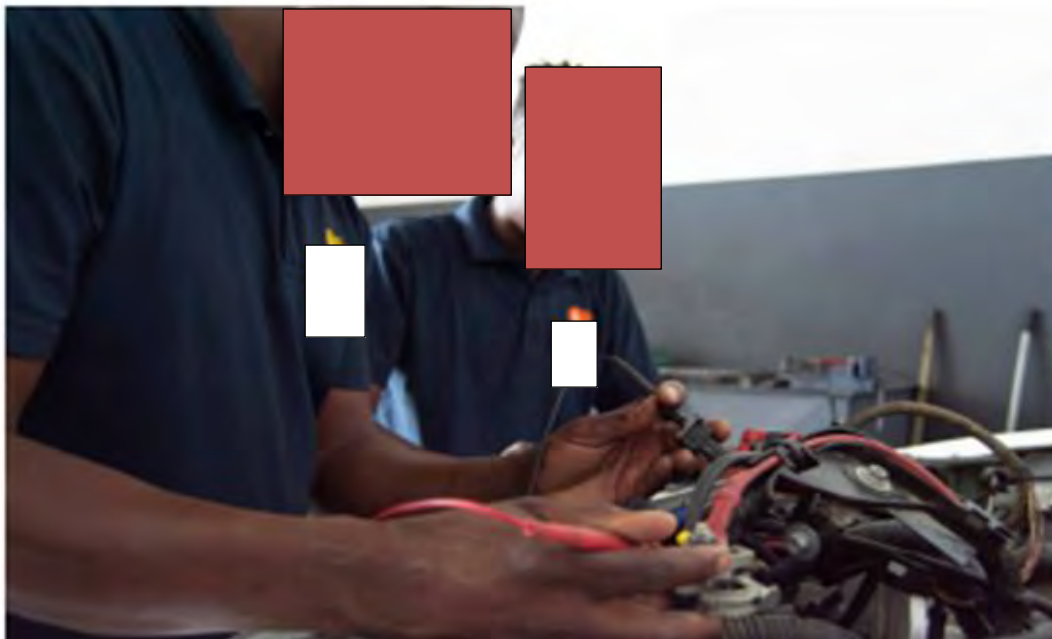


Figure 5.8: Angula with one of his students working on the engine of a vehicle

Figure 5.9 shows Angula and one of his students working on a vehicle's engine during the classroom observation of the practical lesson. The study emphasises that practical lessons blend technology, pedagogy, and content well since students' tools were considered technology within the TVET context. The study argues that Angula could link technology, pedagogy, and content, which is needed to create an interaction between which technologies can be used to teach particular content and under specific pedagogical practices. He sounded confident that enhancing his understanding of TPACK would allow him to expand his knowledge of the three domains. Furthermore, TPACK knowledge would enable him to identify various pedagogical practices tailored to specific topics while integrating technology to enhance their effectiveness. The study indicates that using the right technology to teach particular content would allow students to easily comprehend concepts that may have seemed difficult in the past and make teaching fun.

Angula expressed his eagerness to deepen his understanding of TPACK, aiming to enhance technology integration within the VET context for improved outcomes. The study notes that TPACK understanding would allow the VET context to align with cultivating 21st-century skills, including critical thinking, creativity, collaboration, and communication. The study highlights that incorporating technology into education prepares students for the demands of the digital era and the competencies essential in a swiftly evolving global landscape.

When asked to tick on the TPACK diagram in **Figure 5.4** to indicate his TPACK, Angula ticked on TK, PK, and CK, meaning that he possesses TPACK, which he explained:

I acquired my TPCK during my pre-service training as a VET trainee, during several workshops I have attended, in-service training at NUST, and through self-learning. I also do not rule out continued learning since technology and the curriculum change, as do the pedagogical practices aligning to content and technology.

The quote above states that Angula developed his TPACK through diverse educational experiences, including pre-service training as a VET trainee, attending various workshops, in-service training at NUST, and self-directed learning. He also stresses the importance of ongoing education, as technology, curricula, and teaching methods are continuously evolving.

The study demonstrates that Angula is better positioned and well-equipped with the knowledge to integrate technology into teaching. He has further demonstrated his ability to foster meaningful connections between technology, teaching methods (pedagogy), and subject content, ensuring they work together effectively to enhance learning outcomes. When I asked

him about his view of the “T” position in TPACK concerning vocational training discipline, Angula stated that most of his students were aware of technology and the diffusion of technology into education. He narrates that the need to undergo compulsory technological training since most VET disciplines are technical and technology oriented. Angula also postulated that although he did not have access to technology as he grew up, he was optimistic that there was time to learn, primarily through self-initiated learning or learning from students and fellow TVET teachers. The study reveals that placing technology (the ‘T’ in TPACK) at the forefront or centre of the educational strategy aligns well with VET because these courses heavily rely on technology. In TPACK, technology plays a crucial role alongside pedagogy (teaching methods) and content (subject knowledge). Angula believes that emphasising technology is appropriate for VET since it enhances practical, hands-on learning, which is often technology-based in such fields. He explained:

We have known technology since our pre-service training, although the focus was not on technology integration then. We possess natural knowledge because of the technological devices we own. And that helped a lot in operating technological tools such as laptops and navigating through apps like YouTube.

Angula above reflects on how the early exposure to technology during pre-service training, even without a strong focus on integration, contributed to his familiarity with technology. Angula also acknowledge that his personal use of technologies such as laptops and apps such as YouTube, helped him naturally develop the skills needed to operate technology effectively and navigate digital platforms.

Angula seemed to know how to use technology appropriately. He emphasised that posting notes on WhatsApp allowed students to access and review materials before class, which improved their understanding and made class time more efficient by focusing on discussions, clarifications, and practical applications rather than introducing new topics. Angula also highlighted that technology integration allowed him to use simulations in specific modules, offering a hands-on and interactive learning experience. Simulation is particularly effective for complex or practical subjects, making abstract concepts more tangible. By aligning with experiential learning principles, simulations enhance student understanding through real-world scenarios that would be challenging to replicate in traditional classrooms.

Similarly, I asked Angula why technology was used to teach. Angula narrated that he used technology to enhance his teaching and learning materials, create engaging presentations, and foster a collaborative learning environment for students. He explained:

Technology is vital as it allows me to supplement study manuals and guides with additional information to address content gaps due to curriculum changes, such as the shift to competency-based education.

By leveraging various information sources, I can provide a richer learning experience and ensure that my teaching materials align with current educational standards and practices. This use of technology is crucial for adapting to the evolving landscape of vocational education and training (VET).

The quote emphasises the role of technology in improving teaching by adding current information to traditional study materials. Angula use technology to address content gaps arising from curriculum changes, like the transition to competency-based education. By tapping into various online resources, the teacher ensures that their teaching materials stay relevant and consistent with up-to-date educational standards and practices. This strategy allows the Angula to adapt to shifts in vocational education and training (VET), making technology a crucial tool for staying informed and enhancing the learning process.

Moreover, Angula revealed that he used internet services to access emails, the school website and the LMS, specifically the Blackboard, to search for information that would supplement the content of the study guides while at the same time integrating technology into teaching. He, however, acknowledged that not all topics in the modules that he teaches required the use of technology, and he explained:

Some topics in auto mechanics, such as physical inspection and diagnosis, cannot be taught using technology as it requires students to apply their visual ability to inspect and diagnose mechanical issues. I cannot rule out the use of specific equipment, such as diagnostic tools and scanners, to easily reach areas being inspected and diagnosed.

Angula's remarks above recognises that while physical inspection and diagnosis in auto mechanics require hands-on experience and visual assessment, technology still plays a supportive role. He emphasises the need for students to develop observational skills but also acknowledge that diagnostic tools and scanners can enhance the inspection process by providing access to difficult-to-reach areas.

Angula further acknowledged that integrating technology into teaching was difficult as it seemed to be finding various pedagogical options, reformulating activities and worksheets, and deciding which technologies to support teaching and learning consumed time.

The questionnaire included a question for the participants to self-report on their TPACK. Angula expressed his TPACK proficiency by responding to Likert-type scale items, assigning

values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Angula agreed to all aspects of the TPACK constructs. For example, in terms of TK, he admitted that he could use educational technologies to teach, keep up with some advanced technologies and play around with technologies.

Furthermore, for TCK, Angula agreed that he knew which technologies to use to create a better understanding of the content and which technologies to use for which content, and he could identify technologies that made it easy for students to understand VET concepts. In terms of CK, he admitted that he was familiar with the subject content prescribed by the VET curriculum and the teaching and learning materials specified for the VET discipline and level of trade. He, however, was neutral regarding having sufficient subject knowledge for all his VET trade. This neutrality could be caused by changes in curricula review and the irrelevance of content due to changes in industry needs and evolving information. This study highlights that globalisation and technological advancements would necessitate reviewing and adjusting subject content and curricula to ensure they remain relevant to these developments. Therefore, one cannot claim adequate knowledge of a subject while being aware of the significant global changes, such as climate change driven by CO₂ emissions from vehicle combustion.

Moreover, Angula agreed that he was aware of the need to be flexible and revise teaching styles (PK) to suit both theoretical and practical lessons, considering technology that promoted pedagogical approaches (TPK) and taught specific content (TCK). Concluding his self-report, Angula indicated that in terms of TPACK itself, he could select technologies that strengthened his content, pedagogies, and student understanding, which he could also share with fellow TVET teachers so that they could combine the content with technology and teaching methods. Angula stated that some of his technological tools included projectors, a Blackboard, a laptop and a smartphone. He posited that technology integration was possible because he had to self-learn to improve his knowledge of TPACK. The study demonstrates, therefore, that due to his pre-service training and some of the technology workshop training he attended, Angula had encountered most aspects of TPACK.

When I asked during the semi-structured interview how he ended up using technology, Angula reminisced:

Although I have been using technology in my lessons, an awakening came during the COVID-19 pandemic. The situation worsened because educational institutions were closed, and the government instituted lockdowns nationwide. Interestingly, the government expected teachers to continue teaching despite the COVID-19 breakout. I may not have had a problem with that,

but I cannot imagine what they have gone through to make that possible for those who have not integrated technology into teaching.

Angula acknowledged in the above quote that he was exploring many technologies he integrated into teaching to improve student's learning experiences. He reiterated that when new technologies became available, he would test and try to see whether they would work in his teaching.

Angula revealed that he owned a laptop, a tablet, and a smartphone that were ideal for connecting to the network and supporting teaching. During the semi-structured interview and classroom observation, I noted a few technologies in his class, such as a whiteboard, and a mounted overhead projector with its screen at the adjacent end. He explained that the rest of the technology was related to the discipline and the workshop where practical lessons occurred. Angula reminded me that technology was very costly, and since it kept changing, regular updates would even make it worse for VET centres in terms of being at the same level as the rest of the world. However, providing the relevant technological infrastructure should not be an issue as it would lift the burden off the teachers and students while making access to vocational education easy.

Angula explained that to integrate technology for effective teaching, one must possess TPACK. Then, it comes to an understanding and competencies to select which technologies to use for which content under which pedagogical practices. He continued that the aim was to make teaching and learning practical, promote understanding of concepts, and enhance interactions.

For instance, he stated:

I use my computer to download videos from YouTube, which I then show and discuss with my students through the overhead projector. YouTube videos enable students to understand the topic as visualisation makes it better than mere explanations. However, one should remember that the students we teach are much more technologically infused and are rather technological explorers than us teachers; hence, they might know certain things that we do not. So, they usually step in and say, Sir, can we use this tool/device instead of that to get A or B? They even suggested apps for me to use to get information. Is that not great? Therefore, integrating technology alone may not give us the benefits we anticipate, but collaboratively with the students at the receiving end of the teaching and learning process.

The above quotation clearly shows that Angula integrates technology into teaching; however, he did it collaboratively with the students. Therefore, the study argues that Angula considered student assistance and incorporated them into how he designed his lessons.

When asked how technology assisted him in designing assessment tools such as question papers or worksheets, Angula revealed that he used technology to create mark sheets to record marks, calculate marks, and develop the marking grid. He stated that all these simplified his work and fast-tracked the process of finalising his marks and narrated:

Sometimes, I struggle with questions for examinations or just activities in class, so I always go to YouTube and search for samples of question papers used in other countries in the same course to model my papers. On a different note, it is also easy to keep the marks safely stored compared to having hard copies, which are sometimes misplaced.

The quote above highlights that Angula acknowledges the difficulty of designing exam and classroom activity questions and uses YouTube to access sample question papers from other countries for inspiration. This means that technology is a gateway to help them address some operational and administrative part of teaching.

Angula expressed that because of technology, assessment in some modules was designed so that students were required to submit their work online, allowing the entire marking to be done online. He expressed:

It is easy and much faster to mark students' work online. All I do is upload the assessment online, and students log in to submit it after completing it. This also allows for feedback to be sent to the students instantly.

The quote indicates that Angula appreciates technology for its ability to simplify his work. This is beneficial as it helps him minimise paperwork.

When asked how VET's ICT training on technology changed his pedagogical practices, Angula smiled and explained:

I have no better words to explain that. Teaching has never been this good, simple, and fulfilling. Technology has come to push us out of our comfort zones and help us become innovative and creative while finding ways to show our subjects better. Students' interactions among themselves and myself have improved. Students also explore specific issues related to our lessons and come present to me in class.

This quote shows that Angula highly values the transformative role of technology in his teaching, noting that it has made lessons more effective, engaging, and rewarding. He highlights how technology fosters creativity and innovation in lesson delivery, making teaching more dynamic. Additionally, he emphasises the positive impact on student interactions, as learners actively research lesson-related topics and present their findings in class. This

showcases Angola's recognition of technology as a valuable tool for improving both teaching methods and student participation.

Angula acknowledged that integrating technology into auto mechanics education had transformed his students' learning experience, providing students with more dynamic and engaging ways to acquire essential diagnostics, repair, and maintenance skills. He narrated that technology had made teaching easier by encouraging interactions among students and instructors. He explained:

I favour technology integration because it makes students understand the subject better than just a theoretical explanation. Specifically, by teaching auto mechanics, students learn to interpret data from the diagnostic and troubleshooting tools to identify and troubleshoot problems effectively. Therefore, virtual auto mechanics technologies would allow students to practice without access to physical vehicles, enhancing their understanding of diagnostic procedures.

Angula's remarks above advocate for technology integration in education, particularly in auto mechanics, where it helps students interpret data from diagnostic tools to solve mechanical issues. He also value virtual auto mechanics technologies that provide hands-on practice without physical vehicles, enhancing student' understanding of diagnostic procedures and preparing them for real-world applications.

Moreover, Angula could grasp pedagogical strategies such as flipped learning, which allowed students to demonstrate knowledge and understand concepts better as they learned in two different settings. He reiterated that such a strategy created a supportive and accommodative learning environment.

5.3.5.3.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Angula reminisced that being a VET trainee only equipped him with CK (subject matter) in automotive mechanics. He reiterated that after joining TVET as a teacher, he had to find ways to learn and acquire PK and TK. Angula indicated that he did not need additional formal training but became more explorative and innovative and found ways to learn by accessing various sources of information. He mentioned that exploration could happen through self-initiated learning and other programmes such as workshops, conferences, and seminars.

He also started attending the TVET's ICT training and self-learned to improve his TK from pre-service and post-service training. He stated:

I also acquired my TK from professional experiences when I tried new things and gained best practices from fellow TVET teachers who have been integrating technology into teaching.

The quote above highlights, therefore, that when self-initiate learning, one should consider and relate to previous and prior experiences in the field, highlighted by the SDL theory as one of its principles when planning self-initiated learning.

Angula argues that while some of his TK did not stem from the ICT training provided by TVET, he had to learn independently through trial and error to navigate the technology landscape effectively. As noted in the SDL, this was evidence that learning did not only happen in a formal, structured setup but that individuals could identify their goals, organise their resources, and, through self-assessment, undertake self-initiated learning to achieve such goals.

Moreover, Angula indicated he noticed a lack of specific skills among graduate trainees during their auto mechanics apprenticeships. He then decided to become a TVET teacher but had limited knowledge of pedagogical practices. This knowledge gap encouraged him to enrol in diploma training in TVET at the Polytechnic of Namibia, now NUST, to prepare for classroom teaching. He expressed that the diploma training helped him acquire PK (pedagogical practices), further assisting him in integrating technology into teaching. On such training, he narrated:

The training at NUST equipped me with all the fundamental knowledge on PK required as a TVET teacher and the foundational capabilities to effectively impart knowledge and skills to vocational students in a student-centred approach.

The quote clearly shows that Angula sought opportunities to acquire PK that he was unable to obtain during his TVET training as a trainee.

Angula also explained that he learned his PK and TK from fellow TVET teachers, industry professionals, and experts. He justified learning from TVET teachers because most had successfully integrated technology into their teaching and could share best practices, strategies, and tips with him. Collaboration among VET teachers provided valuable support and practical knowledge for using technology in the classroom. He explained:

Collaborating with colleagues with expertise in technology integration provided valuable peer support as we worked together brainstorming ideas, troubleshooting issues, sharing resources, and fostering a supportive learning community. I benefited from the valuable feedback and opportunities for reflection when I engaged colleagues about their experiences with technology. I have also learned from their successes and challenges, enabling me to refine my approach to technology integration based on shared insights and feedback.

In the quote, Angula highlights the value of collaborating with colleagues experienced in technology integration. This collaborative approach allowed him to learn from others' successes and challenges, refining his methods and improving his use of technology in the classroom.

Further, Angula reminisced about the contextual issues that also came into play because the training environment for TVET teachers differed from the one in which teaching occurred. So, bringing to the classroom what you had learned from elsewhere becomes a challenge, and one needs to think critically of various ways to negotiate the process and contextualise it to your environment, considering the available resources and infrastructure.

5.3.5.3.3 Drivers and constraints for integrating and use of technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

During the semi-structured interview, Angula was asked to describe his self-initiated learning activities that may have helped him integrate technology into teaching. Angula explained that most of his self-initiated learning activities supported him in incorporating technology. He narrated:

For instance, I searched websites like Udemy, Coursera, and Khan Academy, which provide video tutorials, interactive lessons, and assessments to help learners understand various concepts of auto mechanics. I also accessed digital repair manuals and resources on platforms like AllData or Mitchell, where one found information on specific vehicle models, repair procedures, and technical specifications.

The above quote shows that Angula actively seeks online resources, such as Udemy, Coursera, Khan Academy, AllData, and Mitchell, to enhance both his teaching and students' understanding of auto mechanics. These platforms offer video tutorials, interactive lessons, assessments, and detailed repair manuals, which help clarify complex concepts and provide valuable, up-to-date information. By integrating these resources, Angula improves the lessons and ensures that students gain a deeper, more comprehensive understanding of the subject.

Angula also highlighted learning from attending free webinars and virtual workshops conducted by auto mechanics professionals to refresh his mind as they covered specific topics in-depth and provided opportunities for interactive learning. He explained:

These free webinars and workshops provide valuable insights from a broad spectrum of experts in the field, which cannot be found in our teaching materials or within the local expertise. In these webinars, one can also pick up the best pedagogical practices and learn how to link technological pedagogical content knowledge.

Angula's comments above emphasise the importance of free webinars and workshops, which provide unique insights from a variety of experts that are not found in local teaching materials or expertise. These sessions offer opportunities to learn effective teaching methods and deepen their understanding of how to combine technological, pedagogical, and content knowledge.

Angula appreciated having fellow TVET teachers in the field as they served as pillars on which he could lean when he needed them. Angula stated:

I engage others for information, advice, and better teaching strategies to know and understand best practices since some TVET teachers have been integrating technology long before others.

The quote indicates that Angula values learning from more experienced colleagues who have been integrating technology into their teaching practices for longer. By engaging with them, he gains valuable insights, advice, and effective strategies to improve his approach to technology integration.

Angula also acknowledged that he had engaged professionals and experts in the industry physically and online to keep up with the industry trends and know what the industry was looking for from graduates.

Angula concluded that he and his students used YouTube auto mechanics tutorials to see real-world demonstrations. These videos allowed him to analyse the step-by-step processes, pause, and rewind as needed to understand the procedures thoroughly. However, according to the SDL theory, motivation drives self-initiated learning, and TVET teachers should persevere in what they are doing to realise results. Angula further acknowledged that his self-initiated learning was also distracted by noise from his surroundings because he lived where many different business activities occurred. Therefore, he expressed:

Different business activities are concentrated in the area where I live. So, when I try to self-learn at my convenience, it is also the business's time to capitalise on its customers, affecting my concentration and focus on self-learning activities.

This quote highlights how the surrounding business activities and their peak operational times create a distracting environment, making concentrating on self-learning and personal

development challenging. Therefore, the right choice of a space to self-learn undisturbed is essential.

5.3.5.3.4 Harmonising the support that initiates self-TPACK development

This section presents the support Angola believes would help him integrate technology into teaching. When asked during the semi-structured interview about the support he requires to incorporate technology into teaching, Angola feels that TVET teachers are being neglected in terms of support compared to teachers in mainstream education, and he indicated that:

TVET teachers need training on using specific technologies relevant to their field of instruction, including basic technology skills and more advanced tools specific to teaching.

Angula's remarks above stresses the importance of providing TVET instructors with training on both basic technology skills and specialised tools specific to their teaching subjects. This training would enable educators to effectively integrate technology into their lessons, ultimately improving the learning outcomes for students in their respective fields.

He narrated that they (TVET teachers) usually paid for programmes to upskill themselves. Hence, it would just be suitable for the VET institutions to try and do the following:

- Organise platforms such as workshops, seminars, and conferences where local TVET teachers and international experts can share experiences, strategies, and resources related to technology integration.
- Encourage collaboration between TVET teachers and technology experts. Cross-disciplinary partnerships can lead to innovative approaches to integrating technology effectively.
- Pair less experienced TVET teachers with those who successfully integrate technology into their teaching.

Angula emphasises that the government should allocate resources to VET institutions to acquire digital technologies. VET institutions may need financial support to purchase software licenses, update hardware, and access relevant technologies supporting teaching and learning. There is a dire need for infrastructure acquisition and development for the VET sector if TVET teachers were to integrate technology into teaching, and the government is responsible for providing resources to institutions of education.

5.3.5.3.5 Future plans for Angola's technology integration

Angula experiences events that the use of technology has gradually taken up within the VET context. He is optimistic that the VET institutions will soon be valued and funded to acquire relevant technologies that can affect teaching and learning methods and help students grasp complex concepts. Moreover, safety is paramount in the auto mechanics field, and Angula plans to source access to virtual technologies that allow students access to a practical learning environment virtually. By implementing this plan for technology integration, Angula envisions a dynamic and inclusive learning environment that prepares students for the evolving auto mechanic's content. Through the strategic use of technology, he aspires to elevate the educational experience, empower his students, and contribute to advancing his field.

Angula narrated that integrating technology into teaching brought unexpected technical challenges. As a TVET instructor, it is essential to assist students with their technological requirements, including technical support to help them understand how to use their devices effectively. He expressed:

As I integrate more technology into my teaching, I take on the challenge of addressing and solving technical issues for students.

The quote above indicates Angula's readiness to face the challenges he would encounter as he continues integrating technology into his teaching in the future.

Additionally, Angula believed that lifelong learning was critical to comprehending TPACK. Hence, he intends to keep learning and enhancing his technological literacy, as he feels his current TPACK is weak.

Angula aims to study blended learning models further to implement one in his field. He explained that this would help him discover strategies to engage his students through various methods and enable them to show a deep understanding of the material.

Although Angula's pre-service training lacked technology-rich learning experiences, besides professional development and self-initiated learning, he remains optimistic about teaching with technology and values ongoing learning.

5.3.5.3.6 Summary of Angula's case study

Angula, a seasoned and highly respected auto mechanics teacher, has dedicated over a decade to shaping the future of auto mechanics within a VET centre. With a robust foundation in

automotive technology and a profound passion for teaching, Angula has become a pivotal figure in the educational institution, influencing and guiding the next generation of auto mechanics.

Angula's commitment to staying at the forefront of technological advancements in the automotive industry is evident in his approach to teaching. Over the years, he has integrated innovative tools, digital resources, and modern teaching methodologies to enhance his student's learning experiences. His expertise extends beyond traditional methods, encompassing the latest diagnostic software, virtual simulations, and other cutting-edge technologies relevant to the auto mechanics' field.

As an educator, Angula's influence extends beyond the classroom, shaping technical skills and instilling a deep understanding of the importance of technology in the automotive industry. His ability to blend practical experience with contemporary teaching methods positions him as a role model for aspiring auto mechanics, fostering a learning environment that prepares students for success in a rapidly evolving technological landscape. Angula's impact on the institution and his dedication to advancing technology integration underscores his role as a pivotal contributor to the development and progress of auto mechanics education.

5.3.1.4 Iyaloo's case study

Iyaloo was an Oshiwambo speaker aged 31-40 and the only female among the participants. Iyaloo was born into a family of technological enthusiasts, with parents working in the IT industry. Growing up in a tech-savvy household, Iyaloo was exposed to computers and programming languages early. Encouraged by her parents, Iyaloo attended a junior ICT class at one of the private universities while upgrading her matric grades and honing her skills in emerging technologies.

Iyaloo's family enjoyed relative economic stability thanks to the parents' successful technological careers. Iyaloo explored various opportunities for education and personal development in the technology field without financial constraints. With access to resources and mentorship, Iyaloo pursued advanced metal fabrication and welding studies at the Namibian Institute of Mining and Technology. Iyaloo is a Metal Fabrication and Welding VET teacher at the Namwater Vocational Training Institution with over 10 years of experience. Growing up as a reserved and introverted person, Iyaloo did not know she would one day find herself in a male-dominated career. Therefore, Iyaloo could not hide her excitement now that she was

thriving in the industry, an experience she was proud to pass on to her metal fabrication and welding students.

Her professional journey started in the manufacturing sector, where she worked as a skilled metal fabricator, gaining hands-on experience in various fabrication techniques, welding processes, and metallurgy. Then, her expertise expanded as she took on roles that involved project management, quality control, and the implementation of safety protocols in metalworking environments.

Motivated by a passion for metalworking and education, Iyaloo enrolled for a diploma in TVET at NUST to acquire pedagogical practices to enable her to train students in metal fabrication and welding. The course allowed Iyaloo to transition into vocational education, joining a training programme dedicated to equipping aspiring metal fabricators with the skills needed in the industry.

A blend of theoretical knowledge and practical application characterised Iyaloo's instructional approach. Over the years, she has developed and refined her subject content to include various metal fabrication topics, including blueprint reading, welding techniques, sheet metal fabrication, CNC machining, and advanced metallurgy. She narrated that it allowed her to align with current trends and technology integration into education.

In her role, Iyaloo strongly emphasises safety standards and industry best practices. She ensures that students understand the technical aspects of metal fabrication and cultivate a keen awareness of workplace safety protocols and ethical considerations.

Beyond the classroom, Iyaloo actively engages with industry professionals, attending conferences, workshops, and networking events to stay current with advancements in metal fabrication technology and industry trends. This commitment to continuous learning allows her to acquire and integrate the latest industry standards into her curriculum, keeping her students well prepared for the evolving demands of the field. Her constant learning includes self-initiated learning, enabling her to acquire knowledge and skills not acquired in formal education and training.

Iyaloo's impact extends beyond technical skills; she emphasises the development of problem-solving abilities, critical thinking, and effective communication in her students. Her commitment to the holistic development of individuals fosters an environment where aspiring

metal fabricators gain technical expertise and acquire the soft skills essential for success in the workforce.

Her guidance has contributed to the success of numerous graduates who have excelled in various roles within the metal fabrication industry. Notably, Iyaloo's decade-long tenure as a metal fabrication VET teacher is a testament to her commitment to excellence in education and her passion for empowering the next generation of metalworkers with the skills and knowledge needed to thrive in this dynamic and essential field.

5.3.5.4.1 The individual understanding and shifting of TPACK understanding

One of the questions in the questionnaire was for Iyaloo to select the definition that best described her understanding of TPCK. Iyaloo responded by selecting c) (See Table 5.).

Iyaloo struggled to understand TPACK as she described it, comprising the TPCK that TVET teachers needed to possess to integrate technology into teaching. The study reveals that Iyaloo did not have a good understanding of TPACK. During the semi-structured interview, Iyaloo narrated:

I am not sure how to describe my TPACK. I do not even know whether I have selected the correct definition in the questionnaire. She said this may seem awkward, but I am serious about it. I also believe that TPACK is a very emerging concept for me.

The quote above shows Iyaloo's confusion about her understanding of TPACK and whether she correctly identified it in a questionnaire. Iyaloo admits that TPACK is a new and evolving concept for her, highlighting that its too early to fully comprehend its importance and how to apply it effectively.

Iyaloo acknowledged that during the semi-structured interview after our engagement about TPACK, her understanding of TPACK took another turn, and she explained:

I expected it to be something else I did not know or heard before. I am aware of technology. I possess pedagogical and content knowledge. I did not see that one should have the technological pedagogical content knowledge to integrate technology into teaching. Neither was I aware I could abbreviate technological pedagogical content knowledge as TPACK. I also did not know about the TPACK framework. I am hearing about it for the first time.

In the above quote, Iyaloo shares her expectations about technology integration in teaching but was surprised to learn about TPACK. Although she was already familiar with technology, pedagogy, and content knowledge, she did not realise that effective technology integration

requires a combination of all three. Iyaloo also expresses surprise at encountering the TPACK acronym and framework for the first time.

However, Iyaloo admitted that she would like to learn more about the TPACK framework as she believed it would allow her to better reflect on the PCK and enhance her teaching experience with technology. She narrated that a deep understanding of TPACK would allow her to familiarise herself and choose the right technological tools in her lessons aligned with the content and instructional designs.

When asked to tick on the TPACK diagram in Figure 5.4 to indicate her TPACK, Iyaloo responded that her TPACK would be on TK, CK, and PK. Iyaloo explained that she acquired her CK during her VET training as a metal fabrication and welding trainee and learned a few pedagogical practices from her trainers. She did not know that one day, she would be standing in front of a class as a TVET teacher. She stated that the postgraduate diploma in TVET at the NUST shaped and enhanced her PK. Regarding TK, Iyaloo revealed that her upbringing in a tech-savvy environment with access to technological tools, knowledge, and skills from the junior ICT course at a local private university foregrounded her TK.

She narrated:

I am the luckiest person to have grown up in a tech-savvy environment with access to technological tools and gadgets. I know the technical aspects of ICT and could solve any ICT-related problems while teaching. Despite this, I may be unable to balance technology, pedagogy, and content because I possess only technological knowledge and skills.

The above quote reveals that Iyaloo appreciates growing up in a tech-savvy environment that equipped her with solid technical skills and the ability to troubleshoot ICT-related issues. Despite this, Iyaloo recognises that her technological expertise alone may not be sufficient to effectively combine technology, pedagogy, and content in their teaching. This highlights her awareness of the importance of integrating all three components technology, teaching methods, and subject knowledge when applying technology in the classroom.

When asked about her view of the “T” position in TPACK regarding vocational training discipline, Iyaloo highlighted that she viewed the “T” position in TPACK as crucial within the vocational training discipline. Iyaloo narrated that she viewed technology as necessary in TVET because TVET teachers could integrate technology into teaching and learning to ensure students were familiar with the latest digital tools and practices used in the workplace. This

approach would enhance students' technical skills, employability, and readiness to meet industry demands in an increasingly technology-driven job market.

Moreover, she stated that the TVET teachers she interacted with knew about the T since most TVET programmes were technical and technology oriented. She also expressed that the current position of the “T” fitted well with the vocational training. Iyaloo explained:

I am aware of technology and its impact on teaching despite the limited technological knowledge I encounter in my professional work. I believe that awareness has cultivated my interest in learning more about technology and technology integration in teaching.

The quote above highlights the importance of technology and its role in teaching, understanding its impact on teaching. This stance has fueled a growing interest in learning how to incorporate technology more effectively into teaching methods.

Iyaloo emphasises that teachers should be introduced to technology integration during their pre-service training, either before or alongside instruction in pedagogy and content. She emphasised that early exposure would equip educators with the necessary skills and confidence to effectively incorporate technology into their teaching practices. In addition, she posited that the order in which the knowledge domains appeared in TPACK did not matter to her if all the necessary knowledge was instilled and acquired to improve the teaching and learning process. She narrated:

It is not about which knowledge domains come first but whether I (as a TVET teacher) possess such knowledge and can integrate technology into teaching. I am more interested in the interactions between technology pedagogy and content than how they appear within the TPACK concept.

Iyaloo's comments above highlights that the focus should be on whether she has the necessary knowledge and can successfully integrate technology into teaching, rather than the sequence in which the knowledge areas are acquired. Iyaloo is more interested in how technology, pedagogy, and content interact in real-world teaching situations, showing a preference for practical application over theoretical classification within the TPACK framework.

Similarly, I asked Iyaloo her motives for using technology in teaching. She admitted to using technologies daily for multiple reasons, such as searching for information, making teaching presentations and preparing educational materials. Iyaloo stated that the lack of sufficient teaching and learning materials in TVET was problematic and had become a concern for teachers and students alike. She expressed herself as follows:

I develop my teaching materials to supplement what the institutions have provided me. Developing my teaching materials is much easier with technology as I can access online sites and search for content in my field. If I have enough time, I sometimes prepare proper bided packages for my students or make copies for a particular lesson.

Iyaloo's statement underscores the importance to create supplementary teaching materials using technology, which helps her access online resources and find relevant content for her lessons.

Iyaloo further indicated that since the institution where she was employed has full internet access and a computer lab, she could use internet services daily to access email and log onto the institution's website, YouTube, and other search engines. She also mentioned having designed an information site specifically tailored to the current metal fabrication and welding course. She acknowledged using Blackboard to upload documents, create folders, and ensure that all learning materials were accessible to students in a structured manner. Iyaloo also explained that since her institution was new, she sometimes provided technical assistance and support to fellow VET teachers when it became challenging, or they experienced technical problems with their technologies, especially computers and laptops.

The questionnaire included questions for the participants to self-report on their TPACK. Iyaloo expressed her TPACK proficiency by responding to Likert-type scale items, assigning values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Iyaloo reported confidence in her TK, stating that she regularly used educational technologies in her teaching, identified the most suitable tools for specific topics, and leveraged technology to assess student performance. She also expressed strong confidence in her ability to quickly learn new technologies, experiment with them, and apply various technical skills across various tools. She also strongly agreed with keeping up with critical advanced technologies and having extensive knowledge of technology. The study highlights that Iyaloo's TK stemmed from her exposure to and immersion in a technology-rich environment during her upbringing, the junior computer technical course she completed, the computer user skills, and the educational technology module. In addition, regarding CK, Iyaloo accepted that she was-familiar with the subject content as prescribed by the VET curriculum and strongly agreed to be familiar with the teaching and learning materials specified for the VET discipline and levels of trade. In contrast, she was neutral when it came to having sufficient subject knowledge for all her VET trades, and she explained thus:

Subject knowledge is not static because it changes as the latest information emerges. The era that we are in of technology has also contributed to the change in content for my course. So, regular updates and upskilling would be the best thing to do.

Regarding the PK aspects, Iyaloo strongly agreed with changing her teaching styles to suit theoretical and practical lessons. She acknowledged that she had improved aspects of PK through learning from fellow TVET teachers and the diploma she completed at NUST.

Furthermore, on TCK aspects, Iyaloo agreed to know how to use specific technologies to teach specific VET trade concepts/topics and could choose technologies that made it easy for students to understand VET concepts. Regarding TPK, Iyaloo agreed that she could use technologies that promote pedagogical approaches in her lessons. In contrast, on TPACK in general, she acknowledged her ability to integrate technology into her teaching by selecting technologies that enhanced subject content, aligned with appropriate pedagogical approaches, and supported student comprehension. Furthermore, she demonstrated confidence in sharing her TPACK with other TVET teachers and effectively choosing topics that blended subject content, technology, and teaching strategies to optimise learning outcomes.

However, replacing old technologies with new ones becomes costly since technology constantly changes and needs to be upgraded. Iyaloo realised the reality of teaching with technology when COVID-19 came, and the government urged VET teachers to continue teaching while students were home. COVID-19 was the most challenging teaching time Iyaloo indicated having to endure in her teaching career, as some students did not even have access to smartphones, and those who did, did not have mobile networks or data for connectivity to continue learning. She revealed that to worsen the situation, she could only teach the theoretical work of metal fabrication and welding as it was impossible to conduct practical work in contact lessons.

Lastly, Iyaloo highlighted that she experienced inadequate content in the available teaching materials, forcing her to search for information elsewhere. Now, the internet was the right source for additional information to supplement what was in the teaching guides she had. She emphasised that the materials changed often as the latest content emerged and needed to be used instantly. No dedicated printed books existed for various fields, such as mainstream education. During the classroom observation, I noticed students followed the lesson and discussions without teaching and learning materials. Iyaloo explained that there had been network issues the previous day, so she could not make printed copies for the students. When asked how she integrated technology into teaching, Iyaloo indicated that, as mentioned earlier

in the proceeding sections, she used LMS, specifically Blackboard, to organise course materials, assignments, and assessments. She explained that the LMS allowed her to create a blended learning environment where students could access resources and complete tasks online, providing flexibility and accessibility. She stated:

I use the LMS features such as content delivery to upload and distribute learning materials to students. I also use the assessment and testing feature to create and administer assessments like tests, worksheets, and quizzes.

Iyaloo's statement emphasised the critical need for a solid grounding in TK as a foundational requirement for mastering other technology-related knowledge areas. Similarly, Iyaloo described using YouTube to download videos, animations, and interactive graphics that helped illustrate complex concepts and make learning more engaging for the students. She further revealed that she had created mobile learning through a WhatsApp group so that her students could learn at their own pace and access resources anytime and anywhere.

When asked how technology had assisted her in designing assessment tools (question papers and worksheets), Iyaloo explained that during her formal training at NUST, she was trained to use technology, specifically the Blackboard LMS, to design assessment tools and things had never been the same again. Iyaloo stated that she used her laptop to create her assessment tools and would sometimes Google for samples on the internet to use as examples.

In addition, Iyaloo revealed that she and colleagues from other institutions set up a standard assessment tool together, which helped her build her own. She indicated that although she received training on using technology to design assessment tools, her fellow TVET teachers had not. She explained that they would collaborate to develop the assessment while she guided them through the teaching process.

She expressed:

Since I was trained in using Blackboard LMS for designing assessment tools, I have used it several times to upload learning content for my students. I also decided to take my fellow TVET teachers through Blackboard LMS so we could easily design our assessment tools together. Moreover, I have self-learned how to create the assessment tools using Google Forms, mainly when the assessment includes multiple-choice and short-answer questions.

Iyaloo's remarks highlight that the subject knowledge is always evolving as new information emerges. She also observe that technological progress has influenced the content of course. Therefore, she highlight the need to consistently update and improve her knowledge and skills to stay current and maintain effective teaching practices.

When asked how VET's ICT training changed her pedagogical practices, Iyaloo mentioned that she had recognised the potential of technology to enhance both her in-class and extracurricular teaching methods. She had departed from the conventional approaches she previously employed as a TVET teacher. Now, she felt empowered to experiment with new technological resources that aligned with her teaching style, fostering confidence in her abilities. Iyaloo stated that due to the incorporation of interactive tools such as simulations and multimedia presentations, teaching and learning had become more engaging and interactive as students' understanding of complex concepts had improved. Teaching pedagogies were now varied to cater to students with different learning needs and styles. She narrated:

I was used to the traditional methods of teaching in which I focused and followed the content in the study guides; little did I know that there was more that I could do and create such a conducive environment which favoured both my slow and fast students alike. I can also now use Learning Management Systems (LMS) to provide course materials, conduct assessments, and facilitate discussions online, allowing for more flexible and personalised learning experiences.

The quote indicates how Iyaloo initially relied on traditional teaching methods focused on study guide content but later realised the potential to create a more inclusive and adaptable learning environment. She realised that technology, such as LMS, enables her to provide course materials, assessments, and discussions online, offering more personalised and flexible learning opportunities for both slower and faster students.

Moreover, Iyaloo explained that the field and content of the metal fabrication and welding programme focused more on designing styles for cutting, assembling, bending, and welding metals, making it more practical than most trades. Therefore, technology would make learning more interesting because Computer-Aided Design (CAD) software enables students to create precise and detailed 2D and 3D models of metal components. These models enhance students' ability to plan and visualise projects before fabrication begins, promoting accuracy and efficiency. At the same time, Iyaloo revealed that students could now access loads of information online to supplement classroom instructions.

5.3.5.4.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Iyaloo narrated that she independently learned some of the latest content from online platforms like YouTube, building on her prior knowledge and experiences. It is assumed that prior metal fabrication and welding knowledge may have helped

Iyaloo uncover the existing knowledge gap and informed her current self-learning of the latest metal fabrication and welding content.

Moreover, Iyaloo stated that she acquired her PK in two different ways. One was when she was a trainee in the metal fabrication and welding programme. She posited that she vividly remembered how her TVET teachers taught her and her fellow students.

She related:

I thought one day when I became a TVET teacher, I would also teach in the same way that I was taught (considering it was the best at the time). Little did I know that things would not be the same. The training TVET teachers undergo is different, and they have varying styles of teaching; even students of that time were different from those of today.

Iyaloo's statement reflects on her earlier belief that she would teach the same way she was taught, assuming it was the best method at the time. However, she now recognise that teaching has evolved, with TVET training and teaching styles different from what she experienced, while today's students also have different needs. This realisation highlights the importance of adapting to new teaching methods and the changing educational landscape.

Iyaloo explained that the second way she drew her PK was through training for the diploma in TVET at NUST, which enabled her to undergo pedagogical practices coupled with technological skills. She narrated, *"The postgraduate course served as a reasonable basis for me to understand TPACK the way I do and to acquire some PK and TK"*. Iyaloo elucidated that she only thought the CK she acquired was to be used in an industrial setting and did not fantasise about becoming a TVET teacher. She is, therefore, proud that with her CK, PK, and TK, she can select specific technologies related to content and teaching approaches. Iyaloo also acknowledged that the VET's ICT training provided to TVET teachers in 2017 made a difference in her understanding of teaching with technology and eventually moving away from traditional teaching. During the FGD, Iyaloo indicated that it was not easy to integrate technology into teaching after the VET's ICT training because the context in which she received the training was different from the classroom environment. She had to adapt by contextualising the content and applying the training to real-world situations.

5.3.5.4.3 Drivers and constraints for integrating and using technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

During the semi-structured interview, Iyaloo was asked to describe the self-initiated learning activities that might have helped her integrate technology into teaching. Iyaloo stated that the self-initiated learning activities had assisted her in incorporating technology into teaching. Particularly, Iyaloo highlighted that she started accessing online resources, video tutorials, and digital learning materials that facilitated self-paced learning. Furthermore, Iyaloo explained that video tutorials enabled her to obtain a genuine grip on her lessons, knowledge of content, and pedagogies, as the videos included images for students to visualise some concepts. The study highlights that accessing online resources to self-learn equipped Iyaloo with the latest instructional designs and how she could manoeuvre technological devices to balance them and deliver the content. Iyaloo explained that she could find information relevant to her discipline and supplement what was in the study guides she used to teach. She further explained that this information allowed her to understand the various subject concepts not articulated well in the study guides.

Iyaloo also explained that she engaged fellow teachers to seek knowledge and support to integrate technology into her lessons. She narrated:

I have also interacted with my colleagues who have been integrating technology for the past five years on how better one can learn to use and integrate technology in lessons, which helped me to be able to do the same.

The quote indicates that Iyaloo values her interaction with colleagues who have been using technology in their lessons for the past five years, she learned better ways of incorporating technology into teaching.

Iyaloo noted that although learning to teach with technology had many benefits, it came with challenges. She explained:

I encountered fast data usage when watching and downloading a few videos (the data finishes so fast). Sometimes, my laptop starts freezing, which slows and delays the entire learning process.

Iyaloo justified her statement above, clarifying that those challenges delayed her self-learning progress and prolonged her time to complete what she initially planned to cover. She continued that some students were also technologically illiterate, making practicing with them and teaching them the latest pedagogical approaches challenging. In addition, when searching for online information, quite a lot of information popped up, and it became difficult to filter what was relevant to the subject content. Although the information was adequate, Iyaloo stated that it caused so much frustration that she felt like giving up, ultimately focusing only on the information she already had. The study argues that TVET teachers engage in self-initiated learning because they are motivated and have clear learning goals. Consequently, they must remain patient and persevere when encountering challenges.

5.3.5.4.4 Harmonising the support that initiates self-TPACK development

This section presents the support Iyaloo believes would help her integrate technology into teaching. When asked during the semi-structured interview about the support she requires to incorporate technology into teaching, Iyaloo indicated that support is needed in various ways, such as access to technologies with reliable internet connectivity. The study indicates that Iyaloo at Namwater Vocational Training Institution was limited in integrating technology due to the lack of available technologies. Therefore, the Namwater Vocational Training Institution should invest in technological infrastructure to support teachers in incorporating technology into their teaching. The study revealed that when these teachers gained access to technologies reliable internet connectivity, it motivated their self-learning how to use technology in their teaching and to search for information that enhanced their instruction and students' engagement in the classroom. Iyaloo stated:

We need modern technological infrastructure for teaching with technology to have an impact that derives desirable results and outcomes. For instance, the government should assist centres in acquiring Computer-Aided Design (CAD) software and virtual reality (VR) and augmented reality (AR) welding simulators, which allow students to practice welding techniques in a virtual environment.

Iyaloo's remarks above highlight the need for modern technological infrastructure to successfully integrate technology into teaching and ensure desirable results. She proposes that the government should assist educational institutions in acquiring tools such as Computer-Aided Design (CAD) software and virtual reality (VR) or augmented reality (AR) welding simulators. These technologies would enable students to practice welding techniques in a virtual setting, improving their learning experience.

According to Iyaloo, the second support would be regular training, workshops, and seminars to bring experts to train TVET teachers since the technology is also advancing, requiring new pedagogical practices and updated content. It is suggested in this study that regular updating and improvement of TVET teachers' TPACK and skills is essential to close the gap created by technologies.

Iyaloo indicated that thirdly, it might be of benefit if VET institutions appoint technology integration coordinators dealing with specific issues of teaching with technology. The coordinators might help and support TVET teachers when integrating technology and other general technical problems with technological tools.

5.3.5.4.5 Future plans for Iyaloo's technology integration

Iyaloo acknowledges prioritising continuous professional development in technology integration. Continuous professional development includes attending workshops, webinars, and industry conferences focused on the latest advancements in welding technologies, software applications, and digital fabrication tools.

Moreover, she looks forward to collaborating with industry experts to enhance her knowledge and keep her abreast of emerging trends. Iyaloo expressed that engaging and forging a relationship with industry experts would allow her to understand the development of needed expertise and skills required for the job market. She postulated:

Once I understand the expertise and skills required for the job market, I can also obtain the relevant content to impart to my students.

Furthermore, she aims to introduce online resources, instructional videos, and interactive simulations that complement traditional teaching methods. Iyaloo promised to explore integrating VR and AR technologies to create immersive learning experiences. These technologies would allow students to visualise complex welding procedures, simulate real-world scenarios, and enhance their spatial understanding. Iyaloo's plan involves collaborating with technology experts to develop customised VR and AR content for metal fabrication. She stated that:

Integrating VR and AR technologies would require the availability of software such as content creation tools like Unit3D and development platforms such as ARCore and ARkit. Therefore, I hope and plea that the institution can purchase such software to make technology integration sophisticated.

Iyaloo's statement highlights the importance of integrating VR and AR as specialized software, including content creation tools like Unit3D and development platforms such as ARCore and ARKit, into teaching. She is hopeful that the institution will invest in these tools to enhance the quality of technology integration, making it more advanced and beneficial to students' learning outcomes.

Iyaloo was also optimistic that with the explosive discoveries of hydrocarbons in the oil and gas industry, the TVET sector was set to benefit as a service provider for skills and expertise in metal fabrication and welding. She narrated:

I stand ready to receive specific and tailor-made training in metal fabrication and welding for oil and gas to train my students to gain such accolades and contribute to our natural resource extraction.

The quote reveals that Iyaloo is eager to receive specialised training in metal fabrication and welding for the oil and gas sector. Her goal is to equip students with the necessary skills to obtain qualifications and contribute to the natural resource extraction industry. By enhancing her expertise, she hopes to better support students in acquiring valuable, industry-specific skills.

Iyaloo further revealed that TVET would also benefit from relevant services provided by oil and gas, such as specialised courses like drilling and pipeline operations, apprenticeship and internship programmes, and professional development for TVET teachers.

5.3.5.4.6 Summary of Iyaloo's case study

Iyaloo heavily relies on computer technology in her teaching practices, frequently utilising YouTube videos alongside PowerPoint presentations to provide daily lesson summaries. Demonstrating excellent skills in both time and classroom management, she believes that technology, particularly personal computers rather than machines and equipment, aids students in exploring diverse ideas within the realm of metal fabrication and welding.

In addition to her regular use of technology in teaching, Iyaloo has taken the initiative to design and maintain a site of information specifically tailored for the current metal fabrication and welding course. Recognising the evolving landscape of technology, she observes that students increasingly use computer tools, such as computers and downloaded software, to communicate their ideas and results. Iyaloo actively seeks online supplementary materials on the internet, incorporating various digital resources to enhance learning and assessment. She views

technology not merely as a source of digital resources but also as a means of delivering customised answers to students.

5.3.5.5 Nadhipite's case study

Nadhipite, aged 31-40, grew up in a rural village called Mururani, a few kilometres from Rundu in Kavango East, where access to technology was limited. Despite Nadhipite's circumstances, he showed a remarkable aptitude for self-learning and innovation, building makeshift artistic work from old cabinets and spare parts at his house and in the village. Although Nadhipite did not receive formal education in technology and had only attended school up to grade 10, he could not continue to secondary school because there were no finances to pay him to upgrade his grades and qualify for grade 11. So, he decided to follow his talent for artistic work.

Nadhipite's family struggled financially, relying on subsistence farming for their livelihood. The lack of financial resources meant Nadhipite had to overcome significant barriers to access formal education. However, his ingenuity caught the attention of a visiting technology entrepreneur in their community who provided mentorship and resources to develop his skills further. The good samaritan spotted Nadhipite alongside the road to Grootfontein while trying to sell some of his created goods. The good samaritan developed an interest in Nadhipite's artistic work and offered to fund his pursuit of a career in joinery and cabinet making to enhance his talent.

Nadhipite is a highly skilled and dedicated joinery and cabinet TVET teacher at Onembiya Vocational Training Institution, bringing industry experience from the Windhoek Joinery Works where he was employed and a passion for craftsmanship to the classroom. With a career spanning 5-10 years of experience in the joinery field, commitment to excellence in teaching and the development of skilled artisans characterise Nadhipite's journey. Nadhipite's background includes formal woodworking and joinery education and extensive practical experience in residential and commercial settings. Before transitioning to education, he honed his craft as a joiner and cabinet maker, working on diverse projects that ranged from custom furniture to intricate cabinetry installations. This real-world experience is the foundation for his role as a TVET teacher. The experiences he gained as a joiner and cabinet maker moulded him well for a teaching career after realising that he needed to impact people's lives by imparting the necessary knowledge and skills.

Joining the Onembiya Vocational Training Institution as a joinery and Cabinet VET teacher, Nadhipite has played a pivotal role in shaping the curriculum to meet industry standards and evolving trends. His pedagogical approaches cover fundamental woodworking techniques, advanced joinery methods, and modern cabinet-making tools and machinery. The use of modern tools and machinery has set the trend for him to be able to use technology in his classrooms. Nadhipite's classroom is not just a space for theoretical learning; it is a workshop where students actively engage in hands-on projects. Under his guidance, students develop a deep understanding of materials, precision in craftsmanship, and the ability to interpret and create intricate designs. Nadhipite strongly emphasises safety protocols, ensuring that students produce high-quality work and prioritise their well-being in the workshop environment.

One of Nadhipite's strengths is integrating traditional craftsmanship with contemporary practices. His curriculum reflects the latest joinery and cabinet-making advancements, including sustainable and eco-friendly approaches to woodworking. Through partnerships with local industry professionals and participation in woodworking conferences, Nadhipite exposes his students to current industry trends. Beyond technical skills, Nadhipite fosters a creative and collaborative atmosphere in the classroom. He encourages students to explore their design sensibilities and develop problem-solving skills essential in the custom woodworking and cabinet-making industry. His commitment to the holistic development of his students extends to instilling a strong work ethic, effective communication, and a keen eye for detail.

Nadhipite's tenure at Onembiya Vocational Training Institution has contributed to the success of many graduates who have established themselves as skilled joiners and cabinet makers in the industry. Nadhipite built his reputation as a dedicated TVET teacher with a passion for the craft and a genuine desire to see his students succeed in joinery and cabinet making. A harmonious blend of traditional craftsmanship, modern techniques and a commitment to preparing the next generation of artisans for success in a dynamic and creative field characterise Nadhipite's role as a joinery and cabinet making TVET teacher.

5.3.5.5.1 The individual understanding and shifting of TPACK understanding

One of the questions in the questionnaire was for Nadhipite to select the definition that best described his understanding of TPACK. Nadhipite answered by selecting all definitions including the statement of having no idea what TPACK is (See Table 5.).

Nadhipite had never heard of the term TPACK before, evident from his selection when asked to select the definition that best described his understanding of TPCK. He selected all the answers, showing he did not know what TPACK meant or did not understand the question. However, his view of TPACK changed during the semi-structured interview, and he narrated:

After completing the questionnaire, I went and searched for TPACK, read more about it and got to understand the entire concept. I felt foolish for being unable to even guess the correct definition.

Nadhipite's remarks highlight the importance of innovation and creativity. He took the initiative to research the TPACK concept, read more, and developed a better understanding. Nadhipite's efforts to learn and grasp TPACK reflect his dedication to personal and professional development.

This study highlights that Nadhipite's inability to select the correct definition of TPACK could be due to his lack of knowledge about the TPACK framework and the acronym used, which he could not figure out to refer to TPCK.

Nadhipite further indicated that it was vital to understand TPACK because he would have more profound insights into technology integration and eventually develop TPACK. He admitted that although he was new to the TPACK acronyms and framework, it did not mean he had no idea about TK, PK, or CK. He, however, narrated his willingness to learn and understand TPACK in depth as he believed that understanding would enable him to select appropriate technologies that adapted to content and instructional designs. Nadhipite was also confident that understanding TPACK would allow him to entirely do away with traditional teaching and adopt strategies suitable for students with different learning needs and styles. For example, some students learn and understand better through visualisation, while others through demonstrations or discussions.

During the semi-structured interview, Nadhipite was asked to place a tick (✓) on the TPACK diagram in Figure 5.4 to indicate his TPACK. Nadhipite indicated that his TPACK would be on CK, PK and TK. He postulated that enrolling on a joinery and cabinet-making course at the Rundu Vocational Training Institution enabled him to acquire his CK. However, he did not formally acquire PK and TK; instead, he self-learned through other means, such as YouTube and educational videos online.

He expressed:

Self-initiated learning allowed me to understand pedagogical approaches and technological concepts I was unfamiliar with during my training. I did not need formal training again to know such techniques and ideas as my schedule had changed entirely due to teaching.

From the statement above, Nadhipite reflects on how self-directed learning helped him gain a better understanding of new pedagogical strategies and technological concepts that were not part of the formal training. Due to changes in the teaching schedule, he no longer needed formal training to acquire these skills, as he is able to learn independently. This shows that Nadhipite values independent learning and the flexibility it provides in adapting to their teaching needs.

Nadhipite acknowledged that he would need training to be able to use more advanced technologies in his trade, such as CAD software, to create digital and accurate designs as well as digital callipers and laser measuring devices that provided accurate measurements because those were the challenging modules of joinery and cabinet making to students. During the non-participatory observation, I observed how students struggled to get the measurements right because they had to hold the measuring device perfectly. Nadhipite stated:

I cannot ignore that technology is here to stay; unfortunately, it will keep changing and advancing. I need to learn and acquire advanced technological skills to create an interaction between technology, pedagogy and content. I need to understand the latest software, such as CAD, to teach effectively.

Nadhipite's remarks underscore that technology will continue to evolve and play an important role in education. He understands the need to stay ahead by acquiring advanced technological skills to effectively combine technology with pedagogy and content, highlighting the necessity of mastering new tools like CAD software to enhance teaching.

When asked about his view of the "T" position in TPACK concerning vocational training disciplines, Nadhipite indicated that he was aware of technology and technology integration into teaching. Hence, he did not think the T in TPACK should be placed anywhere else because for one to be able to integrate technology, one should possess knowledge of technology, pedagogy and subject content. It would only be fair if all knowledge were acquired together or orderly. Nadhipite also believed that acquiring all knowledge would enable him to create balanced practices when planning his lessons, not overemphasising some and neglecting other knowledge.

Nadhipite mentioned:

Knowing how to create interaction between technology, pedagogy, and content is essential. The interaction ensures that the right technological tool is selected to teach the relevant content using applicable pedagogical practices.

The quote underscores the significance of integrating technology, pedagogy, and content to improve teaching effectiveness. Nadhipite stresses that this integration plays a key role in choosing the right technological tools that complement the subject matter and align with effective teaching strategies, ultimately creating meaningful and impactful learning experiences for students.

During the semi-structured interview, I asked Nadhipite how he used technology in teaching, particularly technology integration. Nadhipite acknowledged having used and still using technology in his classroom and explained:

I have used a projector to show and explain to students the various stages of making a cabinet. I also download online information, print, and give students handouts to help them follow practical design instructions. For instance, I used YouTube videos to download joinery techniques students can learn and use during their practical lessons.

Nadhipite's statement above explains how he integrates technology to support student learning in practical subjects. For instance, Nadhipite uses a projector to visually present the stages of cabinet-making, making lessons more interactive and easier to understand. This approach showcases Nadhipite's commitment to leveraging digital tools to enhance students' comprehension and skill development.

During the non-participatory classroom observation, I observed Nadhipite handing out question papers and reading assessment instructions to the students. Students had various machines and equipment, which Nadhipite indicated were also considered technologies in the TVET context. Students then started measuring, cutting, and assembling pieces of cardboard while Nadhipite looked on and supervised the examination. Further, I observed several technologies that the students used in the classroom, such as saws, routers, milling machines, staplers, and brad nailers. Nadhipite also had access to a laptop, mobile phone, and projector. During the semi-structured interview, Nadhipite mentioned the same technologies and explained how some, such as the router and milling machine, were used to cut and shape the wood as per the design.

Furthermore, during the semi-structured interview, I asked Nadhipite what motivated him to use technology. He revealed that he used digital technology in his lessons to search for information, make teaching presentations, have students work collaboratively, and prepare educational materials.

He postulated:

The content we have available in our study modules is not adequate. Since the industry is changing with technology advancements, we need the latest content that addresses current needs and demands and equips students with 21st-century skills. Likewise, students work better when the teaching pedagogies cater to their varying needs and styles of learning, which makes teaching with technology possible.

Students work much better when I use pedagogical practices accommodating different learning styles. In addition, technology makes teaching and learning fun and increases interactions among them.

Nadhipite's remarks indicate that the existing study modules do not adequately address the evolving needs of the industry, particularly as technology continues to advance. He stresses the importance of updating course content to reflect current industry standards and equip students with essential 21st-century skills. Furthermore, Nadhipite underscores the value of diverse teaching methods that accommodate various learning styles, making instruction more effective. He also highlight how technology enhances student engagement, fosters interaction, and creates a more enjoyable and collaborative learning environment.

Furthermore, Nadhipite highlighted that he used internet services to access emails and sometimes went to the school website for specific information. He also helped students search for all the relevant information from the institution. He further narrated that he also used the LMS, although he did not specify whether it was Moodle or Blackboard. Conversely, he revealed that he had not received any technical support from the institution to fix technological challenges in teaching.

The questionnaire included a question for the participants to self-report on their TPACK. Therefore, the data on Nadhipite's proficiency in TPACK was collected using the TPACK questionnaire. Nadhipite expressed his TPACK proficiency by responding to Likert-type scale items, assigning values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Nadhipite agreed and strongly agreed to all aspects of the TK, such as using educational technologies to teach, keeping up with critically advanced technologies, learning new technologies and knowing which technologies were best suited for his teaching.

Nadhipite also strongly agreed with knowing how to use technology to assess students' performance in the classroom. The study suggests that Nadhipite possessed TK, which enabled him to integrate technology into his classrooms if combined with CK and PK. He noted that using technology in his personal and social life did not necessarily translate into knowing how to integrate it into teaching.

Regarding the CK aspects, Nadhipite strongly agreed he was familiar with the teaching and learning materials prescribed for the VET discipline and the level of trade and agreed he was familiar with the subject content specified by the VET curriculum. However, he disagreed with having sufficient subject knowledge for all his VET trades. Regarding the PK aspects, Nadhipite strongly agreed that he knew how to change his teaching styles to suit both theoretical and practical lessons and which strategies to use to stimulate students' critical thinking in the subject matter. On the TCK aspect, he agreed to know technologies that he could use to understand subject content better, learn how to use specific technologies to teach specific VET trade concepts/topics and choose technologies that make it easy for students to understand VET concepts while on TPK. Nadhipite agreed that he could use technology that promoted pedagogical approaches in his lessons. Moreover, Nadhipite also agreed to aspects of TPACK, such as that he could select technologies to use to prepare and present subject content, pedagogies and students' understanding, he could share his TPCK with other teachers, and he could choose topics that combined the content with technology and teaching methods.

When I asked during the semi-structured interview how he ended up using technology, Nadhipite pointed out that he had been using technology but not to a great extent, as he felt that there was a lot one needed to learn to advance knowledge about technology and meet the students' expected technological standards of learning as most of them were technology savvy.

He expressed:

These students are outstanding. They are more technologically oriented with knowledge than me, and their learning needs and styles have also changed. The course curriculum has also changed to be on par with technological advancements.

The quote above shows how Nadhipite recognises the proficiency of students in technology, often surpassing his knowledge in this area. He acknowledges that students' learning needs and preferences have evolved in response to technological advancements. Additionally, Nadhipite notes that the course curriculum has been updated to keep pace with these changes, ensuring its relevance in modern education and alignment with industry trends.

Furthermore, Nadhipite recognised the need for innovative approaches to enhance his students' understanding and learning experience. As part of this realisation, he embarked on personal initiatives to leverage technology in his instructional methods. The study argues that most teaching practices in VET seem to shift from traditional techniques to including technologies and blended learning. Furthermore, innovative approaches and new pedagogical practices that were more student-oriented emerged to spearhead the teaching and learning process. Nadhipite narrated:

I recognised the potential of technology to cater to diverse learning styles, providing interactive and dynamic content that complemented traditional teaching methods. Therefore, to cater for these diverse learning needs and styles, I needed to adopt new ways of teaching using technology.

This finding reveal that using technology in teaching is necessary because it benefits both the VET teacher and students. Another reason for deciding to use technology, Nadhipite highlighted, was the inadequate teaching resources. These resources, he explained, could be supplemented by technologies to make teaching and learning more fun and beneficial. Some technologies, such as overhead projectors, showed information and visuals that would not otherwise be in the teaching materials. Nadhipite mentioned:

I also use YouTube videos to teach and demonstrate topics that are either unclear in the teaching and learning materials or difficult for the students to understand. Sometimes, students learn and understand better when they listen to someone other than their teacher.

The quote reveals that Nadhipite uses YouTube videos as an additional resource to clarify challenging topics or concepts that may not be adequately explained in standard teaching materials. He believes that visual demonstrations can improve students' comprehension, particularly for difficult subjects. Moreover, Nadhipite observes that students often understand better when the information is presented by someone other than their regular teacher, highlighting the value of varied teaching resources in supporting learning.

Similarly, when I asked how he integrated technology into teaching, Nadhipite described the integration process as a learning experience. He stated that it was not easy at the beginning because he was afraid of not doing it perfectly.

Nadhipite explained:

I may have the necessary technological pedagogical content knowledge; however, balancing such expertise and creating an interaction among them for effective teaching was challenging.

The quote above highlights that although Nadhipite recognises his necessary knowledge in TPACK, he struggles with effectively integrating and balancing these components to ensure successful teaching. The challenge lies in creating a harmonious interaction between technology, teaching methods, and subject matter to improve the learning experience, indicating that applying these elements together in practice is not always simple.

As mentioned earlier, Nadhipite revealed that he used online sites such as YouTube to search for informative videos in his field and incorporate them into his teaching. He also stated that self-initiated learning helped him understand Blackboard, which he now uses to distribute notes to the students so they could learn freely at their convenience.

I asked how technology had assisted him in designing assessment tools (question papers and worksheets). Nadhipite indicated that technology had helped him design most of the activities and projects as well as assessment tasks and mentioned:

I recall that sometimes, I had no idea how to structure my questions and had to employ digital platforms that permitted me to craft customised question papers tailored to various VET courses. These platforms facilitated the integration of multimedia elements, diagrams, and real-world scenarios, thereby elevating the pertinence of the assessments.

Nadhipite's comments highlights instances where he was unsure of how to structure questions and used digital platforms to create tailored question papers for various VET courses. These platforms allowed the integration of multimedia, diagrams, and real-life scenarios, which made the assessments more relevant and engaging. This demonstrates Nadhipite's use of technology to enhance the quality and effectiveness of their assessments.

Nadhipite enlightened that rather than using conventional paper-based worksheets, he shifted to digital platforms that provided interactive functionalities as they enabled students to interact with the content using multimedia elements, drag-and-drop exercises, and simulations pertinent to VET trades. He expressed during the interview:

I use my laptop to download sample assessment papers and contextualise them. However, using technology to mark joinery and cabinet-making assessments is difficult because I must examine what the students have designed, the exact measurements, and cut and assemble pieces.

Nadhipite's remarks explain that he uses the laptop to download sample assessment papers and adapt them to the specific context of their lessons. However, he faces challenges in using technology to assess joinery and cabinet-making work because the process requires hands-on examination of students' designs, measurements, and the physical assembly of pieces. This

reveal that while technology can be helpful in some aspects of assessment, it may not fully replace the need for manual evaluation in practical, hands-on subjects like joinery and cabinet-making.

When asked how VET's ICT training on technology changed his pedagogical practices, Nadhipite recalled that things turned out differently in the classroom. Since participating in the institution's ICT training, Nadhipite experienced a shift in his perspective on teaching with technology. He reported feeling more confident in incorporating educational technology into his teaching. He acknowledged that the institution provided the ICT training to prepare them to integrate technology into teaching. For instance, he stated:

I had to find a way to incorporate what I learned during the training into my lessons because I do not yet have access to most of the technological tools mentioned during the workshop. I also did not forget that the context in which I received training differs from the classroom environment; hence, things turned out differently when in the classroom.

From the above statement, it is clear that it is difficult for Nadhipite to apply what he learned during training to their lessons, particularly due to the lack of access to the technologies emphasized in the workshop. Nadhipite also recognised that the training environment was different from the actual classroom, leading to challenges in implementing the strategies and tools they learned. This indicates that while the training offered useful knowledge, the absence of resources and the disparity between the training setting and the classroom made it hard to effectively apply the concepts.

In addition, technology has generally simplified teaching, “*but I must be cautious because students have different levels of learning, as some are slow and take time to grasp concepts*”. So, Nadhipite posited that the technologies he selected for teaching and learning a particular topic were carefully selected to support learning styles and be inclusive to all students.

Nadhipite further stated that the institution's ICT training had solidified his understanding of his role as a TVET teacher while allowing him to experiment with new instructional practices, helping him become more comfortable and confident with them.

5.3.5.5.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Nadhipite claimed he acquired his TPACK from various sources. He revealed that he mainly obtained his CK from his pre-service training, which he underwent many years ago (a decade) as a trainee in VET. He postulated that the training was

necessary because it enabled him to acquire the relevant CK needed for the job market and impart such knowledge to the students in VET. He further narrated that the VET curriculum had prescribed the CK, although there might have been new developments here and there. He explained:

The new developments are making me a self-learner so that we are updated in our content and obtain the latest information in line with globalisation and the skills I should impart to today's students. These students are technologically advanced and require 21st-century skills to better prepare them for the demanding job markets in the 4IR and the following IRs.

The above stance highlights Nadhipite's acknowledgements that new developments in technology are pushing him to become a self-learner in order to stay updated with current content and knowledge. He emphasises the importance of equipping students with the latest skills in line with globalisation, as today's students are highly technological advanced. The teacher recognises the need to prepare students for the future workforce by providing them with 21st-century skills, ensuring they are ready for the challenges of the Fourth Industrial Revolution (4IR) and beyond.

Moreover, Nadhipite narrated that he never really cared about the pedagogical approaches used by his teachers during his pre-service training as he never intended to become a TVET teacher. However, as the tables turned, he could relate to and draw some of his PK from that experience. Nadhipite stated that as the pedagogical practices changed from teacher-centred, considered traditional teaching, to student-centred, he also had to self-initiate learning activities to upgrade and improve his PK to align with the student's needs and learning styles. He expressed:

I had to enrol in the diploma in TVET at the Namibia University of Science and Technology (NUST). This helped me integrate technology into my lessons because the trade is technical and uses more machinery. I also needed the pedagogical practices to balance technology, pedagogy and content. I still needed to self-learn to create the interactions between the three domains.

The above statement reveals Nadhipite's reflection on his decision to pursue a diploma in TVET at NUST to enhance his ability to integrate technology into their lessons, especially given the technical nature of their trade, which involves machinery. He acknowledges the importance of combining pedagogical practices with technology and content to create a balanced approach to teaching. However, he also recognises that self-initiated learning remains crucial for effectively combining these three elements in their teaching methodology.

Moreover, Nadhipite indicated that he acquired his TK from self-initiated learning activities such as accessing online sites like YouTube and courses offering various technology programmes. He stated:

I needed to refresh what I had learnt from other sources while at the same time learning other new concepts and ways of integrating technology into teaching. There are always new search engines and other sites of information I may not have come across before or never existed at all then.

In the above quote, Nadhipite recognises the importance of revisiting and reinforcing previous knowledge while staying open to new ideas and methods for integrating technology into teaching. He acknowledges that with new search engines and information platforms constantly emerging, it's crucial to continue learning and adapting to keep pace with technological advancements.

He also pointed out that he had acquired his TK from fellow TVET teachers who had been incorporating technology into teaching for some time, and he explained:

We could come together in a group and share ideas and best practices. It was also an excellent platform to transfer knowledge, especially to those doing it for the first time, like me.

The quote above highlights the importance of collaborating with colleagues in group settings to share ideas and best practices. Nadhipite sees this as a valuable opportunity for knowledge transfer, especially to him as the new TVET teacher to the practice, as it helps him learn and grow through shared experiences.

Nadhipite also acknowledged that the ICT training provided by the institution and other professional development programmes, such as workshops and community of practice, contributed to his CK, PK, and TK.

5.3.5.5.3 Drivers and constraints for integrating and using technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

Nadhipite had undertaken various self-initiated learning activities that helped him integrate technology into teaching. During the semi-structured interview, Nadhipite mentioned that he often accessed YouTube videos using the laptop provided by the institution to draw lesson content and learn from other teachers who integrated technologies into teaching. Furthermore,

through self-learning from YouTube videos, he designed instructional videos demonstrating woodworking techniques, safety protocols, and project guidelines. Instructional videos and online tutorials provided students with on-demand access to valuable resources. He expressed:

I searched for more understandable information for my students, which I downloaded and forwarded to them. This information is pertinent as the content in the study modules is inadequate and not recent. Some information is better if presented in diagrams, pictures or visualisation of any kind, and it steers the interactions among students and between them and me.

Nadhipite's statement above shares his initiative to find clearer, more relevant information for students by seeking additional resources beyond the outdated study modules. He recognises the importance of visuals, such as diagrams and pictures, to boost student engagement and encourage active interaction within the classroom.

The study highlights that YouTube videos were the most popular source of information for VET teachers integrating technology in teaching compared to other sources such as e-books, online databases, journals, and websites or blogs.

Furthermore, Nadhipite engaged his fellow VET teachers from other VET institutions for assistance and support in accessing online content and integrating technology into teaching. He narrated that the engagement enhanced communication and encouraged information sharing among TVET teachers, contributing to students' understanding of various technical and theoretical concepts. Nadhipite indicates:

Many VET teachers are technologically advanced and have been ready to share the recipe for integrating technology into teaching. It is argued in this study that VET teachers collaborate by sharing expertise, successful stories and best practices to become better at their work and cooperatively perfect the teaching and learning process.

The above statement highlights the technological skills of many VET teachers who are willing to share their expertise in integrating technology into teaching. The study underscores the importance of fostering collaboration among VET educators, as it allows for the exchange of knowledge, success stories, and best practices. This collective effort helps teachers improve their skills and contributes to enhancing the overall teaching and learning process.

However, Nadhipite experienced challenges when self-learning to integrate technology. He indicated that limited knowledge about the online sites where to get information had hindered his self-learning in incorporating technology. He postulated that searching for information took longer than anticipated, causing unnecessary delays, and he alluded:

Our internet network is not so good, one time you are on and other times it becomes inactive, and the data is so expensive and faster when you try using them at home. I also experienced an overload of information, some of which was not relevant to what I was looking for, and that required patience and discipline to filter out what was needed.

The quote indicate that Nadhipite faces difficulties with unreliable internet connectivity and expensive data, especially when used at home. He also deal with information overload, requiring patience and discipline to sift through irrelevant content and find what is useful for their needs.

Nadhipite highlighted that self-initiated learning was not an easy task. Thus, one needed to carefully plan it according to the goals one intended to achieve.

5.3.5.5.4 Harmonising the support that initiates self-TPACK development

This section presents the support Nadhipite believes would help him integrate technology into teaching. When asked during the semi-structured interview about the support he requires to incorporate technology into teaching, Nadhipite emphasised that TVET teachers needed training to acquire and understand TK, PK and CK. He emphasised workshop discussion forums, guided practice, and individual consultations with industry experts would support TVET teachers in developing TPACK. The study argues that frequent training sessions or ICT workshops would help TVET teachers discover methods to incorporate technologies into lessons and assignments, enabling students to share and engage with each other's reflections and analyses of course concepts.

Ongoing training is essential to keep me up-to-date with current developments. Everything, from content to pedagogy and technology, is constantly evolving. Business as usual is no longer sufficient.

Nadhipite's remarks emphasise the importance of continuous training to stay informed and adapt to the ever-changing landscape of education. He recognises that content, teaching methods, and technology are all evolving rapidly, and simply maintaining the status quo is no longer enough to ensure effective teaching.

Another support Nadhipite highlighted was TVET teachers' transfer to developed nations with well-established TVET systems to learn and understand the best practices for integrating technology in teaching. This finding highlights that TVET teachers need international exposure and benchmarking to provide them with global best practices and strategies for improvement while enhancing collaboration.

Nadhipite further indicated that the government, through the NTA, should introduce short courses for TVET teachers to upskill themselves regularly, improve their CK, PK, and TK, and be able to integrate technology in teaching. He believes this would allow TVET teachers to acquire some knowledge and skills in technology, pedagogy, and content over a short period.

Moreover, Nadhipite postulated that most freely accessible online content is often irrelevant to the Namibian VET curriculum. He proposed that institutions subscribe to educational platforms aligned with the VET curriculum, enabling TVET teachers to explore diverse teaching resources relevant to their needs. The finding is important as pertinent information would help TVET teachers to directly go to sources with relevant information about their discipline and context rather than wasting time. This finding reveals that TVET teachers need to know the various sources from which to search for pertinent information to integrate technology into teaching.

Nadhipite also expressed the skills he acquired during most of the ICT training he attended. He stated:

Most of the training I attended provided only general technological skills, which became challenging for me to practice and use after exercise. Therefore, I suggest that TVET teachers be provided with tailor-made Technology Training Workshop sessions focusing on the practical use of technology tools relevant to the subject matter.

The quote shows how Nadhipite reflects on his experience with training programs that primarily covered general technological skills, which he struggled to apply in his teaching. He argues that he would gain more from tailored workshops that focus on the practical use of technologies specific to their subjects, making it easier to incorporate technology into teaching.

Nadhipita emphasised that while TVET teachers need training, it is crucial that the training aligns with the curriculum and equips them to achieve their teaching and learning objectives effectively including technology integration.

5.3.5.5.5 Future plans for Nadhipite's technology integration

Nadhipite has a distinct approach to integrating technology and TPACK. While many other TVET teachers are content with current technological offerings, Nadhipite actively seeks a balance between existing capabilities and potential advancements, exploring the intersection of what is feasible and what could be introduced.

Nadhipite indicates that since technology is here to stay and will keep changing, he intends to continue learning to improve and upgrade his skills and knowledge on all TPCK aspects. Continuous learning would enable him to keep up-to-date and on par with the changing technology.

Furthermore, he plans to train more young people in joinery and cabinet making in content and pedagogy to leave a legacy of trainees who can pass on the knowledge to others and carry the VET torch for a sustainable future. Nadhipite also indicates the need to acquire and incorporate CAD and AR technologies in his lessons to design 3-D and 2-D for joinery and cabinet making. He said this would simplify students' process of creating and measuring manually to obtain the perfect design and measurement. He expressed:

It is not easy for students to obtain exact measurements of designs manually, so with technologies such as CAD and AR, students' learning and practical work would become more manageable and better.

Nadhipite acknowledges the absence of studies on TPACK in TVET in Namibia. Hence, he plans to enrol in a master's in education programme focusing on TVET to research TPACK, contributing to existing knowledge on technology integration and TPACK in TVET. He posited:

It is worrisome that we do not have studies on TPACK done in the field by our TVET teachers. Therefore, one way to transfer knowledge on TPACK is to encourage TVET teachers to study further and collaborate with scholars to undertake such studies. This will allow TVET teachers to come after us to learn about TPACK, unlike us.

Nadhipite stresses the importance of the institution's technical support in ensuring regular maintenance of all technologies over several years. He reassured that many courses would be upheld in their current format for the coming years, as the curriculum and classroom technology were expected to remain unchanged.

5.3.5.5.6 Summary of Nadhipite's case study

Nadhipite is inclined to incorporate real-life problems, which he sees as a backbone for his teaching. Concerning integrating technology in teaching joinery and cabinet making, he believes that computer technology empowers students to explore various ideas and suggestions and experiment with different models. His teaching methodology heavily relies on his pedagogical expertise, leading him to set high expectations for himself in seamlessly

integrating technology, ensuring a comprehensive coverage of students' instruction from various perspectives.

An assessment of Nadhipite's TPACK highlights that content and pedagogy remain his most robust constructs. At times, through self-learning, he exhibits perfectionism by thoroughly familiarising himself with technology before introducing it in the classroom so that he is sure that it will also work for his students. He tends to confirm a technology's efficacy through hands-on experience, dedicating significant time to mastering every detail. When he integrates technology into his teaching, he does so with a positive mind that the planned lesson is delivered exceptionally well.

5.3.5.6 Iyambo's case study

Iyambo, aged between 50 and 60 (only a few years to retirement), was born and raised in Zambia, a rural setting where technology did not exist. As a rural village boy, Iyambo's family faced economic challenges due to employment uncertainty and increasing living expenses. So, they left Zambia for Namibia via the TransKarahari Highway. He pursued his National Trade Diploma in Airconditioning and Refrigeration in Namibia at the Zambezi Vocational Training Institution. Iyambo took on part-time jobs and sought scholarships and grants to support his education and pursue his passion for technology. Iyambo is an exemplary figure in VET, boasting an impressive 26-years tenure as an air conditioning and refrigeration TVET teacher. His extensive experience positions him as the longest-serving TVET teacher at Nangolo Keendjele Vocational Training Institution is a testament to his unwavering commitment to educating and shaping the next generation of heating, ventilation, and air conditioning professionals.

However, before venturing into education, Iyambo accumulated years of practical knowledge working as an air conditioning and refrigeration technician in the government. This real-world experience not only equipped him with technical expertise but also instilled in him a deep understanding of the challenges and advancements within the sector.

Iyambo continued with education and obtained a degree in science education from the University of Namibia, after which his teaching journey began with a solid foundation in heating, ventilation, and air conditioning technology, complemented by hands-on experience in the field. So, joining the VET institution over two decades ago, Iyambo has been instrumental in developing and refining the air conditioning and refrigeration curriculum. His

instructional approach is a harmonious blend of theoretical concepts and practical applications designed to give students a comprehensive understanding of heating, ventilation, and air conditioning systems, refrigeration cycles, and environmental control technologies.

One of Iyambo's key strengths lies in his adaptability to technological advancements within the HVAC industry. Over the years, he has consistently updated the curriculum to incorporate the latest developments in energy-efficient systems, intelligent technologies, and environmentally sustainable practices. This forward-thinking approach ensures that his students are well-versed in traditional HVAC principles and ready for the industry's evolving landscape. During the classroom observation, I observed that Iyambo prepared daily lessons for the next day, building upon the previous day's work. The lesson preparation guided him in knowing what topic to teach, what pedagogical strategies to apply, and what technological tools to use (if any) because not all topics can be taught using technology. The lesson preparation also included assessment activities for homework and projects, which Iyambo gives students depending on the subject. Unfortunately, refrigeration components were the only technology used in this lesson plan. Below is an example of a standard air conditioning and refrigeration lesson plan.

Institution: [REDACTED]	Trainer: [REDACTED]
Learning area: Air conditioning and Refrigeration	Level: 2
[REDACTED]	Duration: 1H:10 minutes
Context: The Air conditioning system	
Specific Learning Outcome: 1. The trainees must be able to understand the air condition system 2. Air-conditioning operation. 3. Identify the fundamental process of the cycle 3. Know the principal parts of the air conditioning system	
Lesson Objectives the trainees must be able to: - Define the air conditioning system. - Identify the air conditioning system's parts. - Explain the air conditioning system's operation.	
Teaching methods: - Lecturing - Discussion - Demonstration	
Assessment Strategies: oral questions, test at the end of the lesson session	
Trainee Activities: Listening carefully, asking questions and answering questions	

Time	Process steps	Teacher/Trainer activities	Student/Trainer activities	Resources
20 min	1. Recap from the previous lesson. - What is the air conditioning system? - Mention several operational of air conditioning system.	Asking questions to recap from the previous lesson	Answering questions	Chalkboard, textbook
30 min	2. INTRODUCTION Topic: Refrigeration system Learning Objectives - Explain the air conditioning system - Identify components in the air conditioning system - Explain how air conditioning system works	Introduce the new topic and asking questions	Asking questions where they do not understand	Chalkboard, textbook handouts
15 min	3. DEVELOPMENT/PRESENTATION Air conditioning: Heating, Cooling and Ventilation - Define air conditioning system. - Identify the air conditioning system components. - Explain the air conditioning system's	Explain the definitions	Listening Taking note	Chalkboard, refrigeration components

Figure 5.9: Lesson plan for air conditioning and refrigeration

In the classroom, I observed that Iyambo fostered a dynamic and interactive learning environment. He encouraged hands-on experience, allowing students to work with actual HVAC systems and tools commonly used in the field. His commitment to safety standards was paramount, ensuring students developed technical skills, a strong sense of responsibility, and adherence to industry best practices. Beyond technical knowledge, Iyambo emphasised the

importance of soft skills in the HVAC profession. Effective communication, teamwork, and problem-solving were woven into the fabric of his teaching philosophy, preparing students for technical proficiency and success in the HVAC industry's collaborative and service-oriented aspects.

Iyambo's longevity as an air conditioning and refrigeration instructor is a testament to his passion for teaching and his dedication to the success of his students. Many of his graduates have established successful careers in the HVAC field, reflecting Iyambo's impact on shaping skilled professionals in the industry. Therefore, he stands as a pillar of expertise and mentorship in the VET community, embodying a commitment to excellence, continuous learning, and the holistic development of HVAC professionals over two and a half decades.

5.3.5.6.1 Individual understanding and shifting of TPACK understanding

One of the questions in the questionnaire was for Iyambo to select the definition that best described his understanding of TPACK. Iyambo selected d) (See Table 5.).

Iyambo understands TPACK very well. He selected TPACK as a framework to describe the knowledge TVET teachers needed to implement effective pedagogy in a technology-enhanced learning environment. During the semi-structured interview, Iyambo acknowledged that he was well informed about TPACK, hence the way he understood it, so he explained:

I went through training for the postgraduate diploma in TVET at NUST. I had an opportunity to interact with professionals in the sector who, by virtue, introduced and recommended that I read journal articles on TVET. It is from these interactions that I came across the TPACK concept.

In the quote above, Iyambo reflects on his training for a diploma in TVET at NUST, where he had the opportunity to connect with professionals in the industry. These interactions encouraged him to explore journal articles on TVET, which ultimately introduced him to the concept of TPACK.

Therefore, TPACK was not new to Iyambo, as he had extensive experience and had read numerous research articles on science education and the use of technology in teaching it. The question should be, how did Iyambo manage to understand TPACK better than his fellow VET teachers? In addition to Iyambo's narratives in the preceding section, he revealed that he undertook self-initiated learning activities such as using his laptop to access online sites to understand TPACK and watching YouTube videos explaining technology integration and

TPACK development in education. Iyambo recounted that understanding TPACK was necessary because it allowed him to differentiate between the three knowledge domains and create an interaction for effective teaching. Iyambo postulated thus:

After reading journal articles, I realised I needed a lot of information on TPACK, so I accessed online sites such as YouTube for educational videos on TPACK. TPACK understanding enabled me to adopt new technologies in my teaching, change my pedagogical practices, and become recent in terms of subject matter so that it is on par with current trends and development.

Iyambo's reflections above indicate his efforts to gain a deeper understanding of TPACK after reading journal articles. Recognising the need for more knowledge, he explored online platforms such as YouTube for educational videos on the topic. This increased understanding of TPACK allowed him to integrate new technologies into teaching, adjust pedagogical approaches, and update his subject matter to stay aligned with the latest trends and advancements in the field.

However, Iyambo admitted that although he had some prior knowledge about TPACK, learning did not stop as new technologies emerged, requiring different understandings, primarily focusing on VET. He indicated he was more than willing to engage in research, adopt better ways of integrating technology in teaching, and develop TPACK.

During the semi-structured interview, Iyambo was asked to tick on the TPACK diagram in Figure 5.4 to indicate his TPACK. Iyambo ticked CK and TK, which means he possessed content and technological knowledge. Since Iyambo possessed both CK and TK, his TCK would also be evident, as shown in **Figure 5.4**. Moreover, Iyambo indicated that he had learned most of his PK and advanced TK by himself (self-initiated learning) because all his qualifications (National Trade Diploma in Air Conditioning and Refrigeration and degree in science) only enriched him with CK and a little bit of TK from a module on technology as part of the curriculum. During the semi-structured interview, Iyambo indicated that one of the aspects besides teaching methods covered in his CK was classroom management. The study argues that class management is vital as it helps to keep students engaged and focused on the teaching and learning process. He explained:

One way I control my classes is by keeping a class attendance and letting every student sign upon coming to class. The exercise keeps me knowing whether all students are coming to class.

The above quote highlights how Iyambo managed his classes by maintaining an attendance record, with each student signing in upon arrival. This approach allows him to monitor attendance and confirm that all students are attending class consistently.

Below is a class attendance list for the air conditioning and refrigeration class for level 1 students.

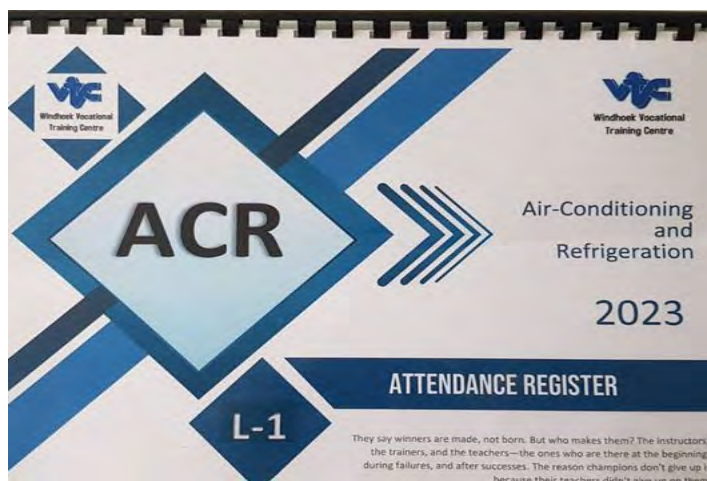


Figure 5.10: Class attendance for air conditioning and refrigeration

When asked about his view of the “T” position in TPACK concerning vocational training discipline, Iyambo acknowledged being aware of technology. However, he was initially resistant to change and had a negative attitude towards it, which made him act as if he was unaware of what was happening around him. He indicated that the “T” position needed to remain at the beginning of TPACK because institutions should train TVET teachers on using technology during their pre-service training to make a combination and linkages between technology, pedagogy, and content. Iyambo further explained that integrating technology into teaching would make teaching and learning easy and flexible. This finding indicates that TPACK, in terms of the order or position of the constructs, should be the same in VET as in any other context.

During the semi-structured interview, I asked Iyambo how he used technology in teaching, explicitly how he incorporated technology into his teaching. Iyambo mentioned that technology served as a tool for both teaching and learning, emphasising its role in aiding students' comprehension of various air conditioning and refrigeration concepts. He clarified that he used technology to enhance teaching rather than replace the traditional approach entirely. Apart from the machines and equipment for air conditioning and refrigeration, I observed that Iyambo had

access to a laptop, a desktop, overhead projectors (old versions), and the advanced overhead projector mounted on the wall, as indicated in Figure 5.12.



Figure 5.11: One of the classrooms used for air conditioning and refrigeration lessons

It is clear from Figure 5.12 that Iyambo had access to various technologies, which allowed him to transform the teaching approach, providing fresh viewpoints and a significant departure from traditional chalkboard methods. In addition, technology can increase students' interest in air conditioning and refrigeration. During the semi-structured interviews, Iyambo mentioned the same technologies as was observed in the class during the classroom observation, he noted:

I have access to a laptop, a desktop, overhead projectors (old versions), and the advanced overhead projector mounted on the wall. I also have access to the black and whiteboard in my classroom. Additionally, I consider all machines and equipment in the air conditioning and refrigeration trade as technology. I cannot separate technology from the trade itself because it is technical.

In the above quote, Iyambo outlines the range of technologies and equipment he has in the classroom, such as a laptop, desktop, old and modern overhead projectors, and both black and whiteboards, highlighting that technology is an integral part of the technical nature of the trade and cannot be separated from it.

Below is some equipment, including gas cylinders, found in the air conditioning and refrigeration laboratory, where students carried out hands-on activities and performed practical assessments.

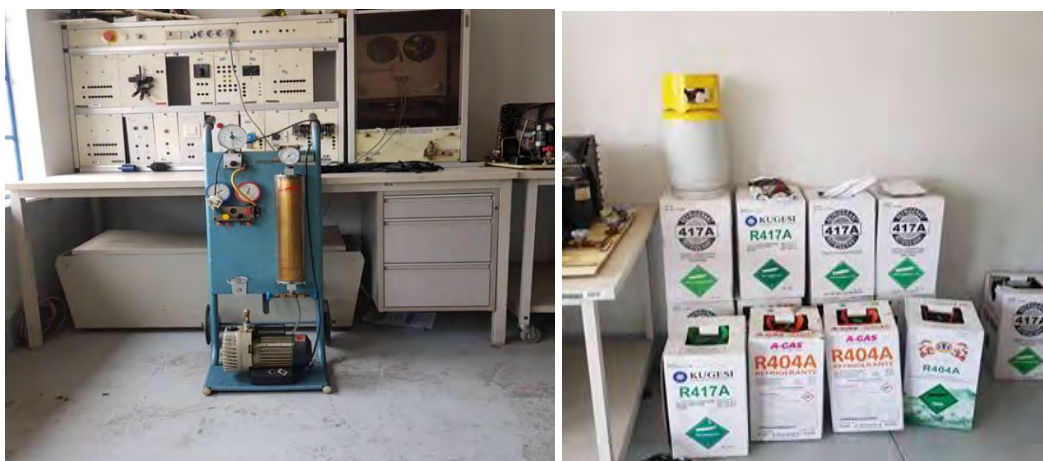


Figure 5.12: Laboratory for air conditioning and refrigeration

The equipment and machine shown in Figure 5.13 are considered technologies, as Iyambo narrated earlier. Iyambo added that in a TPACK-focused teaching environment, the machines and equipment are hands-on tools that connect technology, teaching methods, and subject knowledge. He explained:

I use the machines and equipment to familiarise students with industry-specific technology like gas cylinders. I use demonstration as a pedagogical approach to show students how to operate the equipment or machines.

The above quote describes how Iyambo uses machines and equipment in the classroom to familiarise students with industry-specific technology, such as gas cylinders. He adopts a demonstration-based pedagogical approach to teach students how to operate these tools and machines effectively.

Iyambo indicated that TVET was one of the educational sectors facing a lack of teaching and learning materials; hence, technology was used to source and prepare educational materials. Instructors cannot find these materials in textbooks, so he postulated:

Iyaloo outlines the range of technological tools and equipment they have in the classroom, such as a laptop, desktop, old and modern overhead projectors, and both black and whiteboards. They also consider all the machines and equipment used in the air conditioning and refrigeration trade as part of the technology, highlighting that technology is an integral part of the technical nature of the trade and cannot be separated from it.

Iyambo acknowledged using technology through internet services to access emails, school websites and Blackboard. He posited that he sometimes receives technical support from the system administrator/ICT coordinator at his institution when he faces technical problems. He mentioned:

I prefer to use diagrams for visualisation, especially in the control module, where students learn about control devices that monitor and regulate various parameters such as temperature, pressure, and humidity.

The above quote reveals that diagrams assist in simplifying and clarifying these concepts, enhancing students' comprehension of the material.

During the semi-structured interview, Iyambo described that during the ozone-depleting substances topic, particularly hydrochlorofluorocarbons, he searched for a picture depicting lower global warming potential technology as alternatives to hydrochlorofluorocarbons and hydrofluorocarbons used in the previous generation. The new technology provided the best energy efficiency, safe operation, competitive costs, and good environmental performance in high-temperature countries.



Figure 5.13: A picture of global warming potential technology used to lower ozone-depleting substances

By employing technology in this manner, Iyambo acknowledged that technology had grown beyond being just a tool and had become a valuable partner in teaching. Iyambo was amazed because students could detect wrong connections and notify him, and then, collaboratively, they could figure out the correct connections until they obtained the desired results. Thus, Iyambo integrated technology not on his own but with the support of his students, who were often the most technologically savvy in the classroom. Iyambo stated that the students shared their TK, helped with troubleshooting, and provided insights into new tools, making integrating technology more effective and relevant.

The questionnaire included a question for the participants to self-report on their TPACK. Data on Iyambo's proficiency in TPACK was collected using the TPACK questionnaire. Iyambo expressed his TPACK proficiency by responding to Likert-type scale items, assigning values such as 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

Iyambo strongly agreed with all aspects of TPACK. For example, regarding TK, Iyambo firmly accepted that he could use educational technologies to teach, learn new technologies quickly, and know which technologies were best suited for his teaching. On CK, he strongly agreed he was familiar with the subject content as prescribed by the VET curriculum, had sufficient subject knowledge for all his VET trades, and was familiar with the teaching and learning materials specified for the VET discipline and level of trade.

Regarding PK, Iyambo strongly agreed that he could change his teaching styles to suit theoretical and practical lessons. At the same time, on TCK, he narrated that he knew how to use specific technologies to teach specific VET trade concepts/topics and could choose technologies that made it easy for students to understand VET concepts. He knew technologies that he could use to understand the subject matter better. Iyambo also strongly agreed regarding TPACK, such as selecting technologies to prepare and present subject content, pedagogies, and students' understanding, sharing his TPACK with other TVET teachers, and choosing topics that combined the content with technology and teaching methods. The findings indicated that Iyambo distinguished himself as knowledgeable in all TPACK constructs. He stressed that his expertise stemmed from consistently engaging in workshops and seminars on integrating technology.

When I asked during the semi-structured interview what prompted him to use technology, Iyambo stated that he needed to access important information that was only possible through technology. Technology provided him immediate access to vast information, resources, and educational materials, breaking down geographical and time constraints. In his own words, Iyambo postulated:

The internet I have used allowed for real-time updates and access to the latest research, data, and educational content. I could also access digital tools, multimedia resources, and interactive content that captured students' attention and made learning more engaging. The assessment phase of the teaching process is challenging, so I needed to automate that and move away from the manual marking of sheets and question papers. I, therefore, used technology to streamline the assessment process through online quizzes, automated grading systems, and data analytics. Using technology allowed me to provide timely and detailed feedback to students, allowing for a quicker understanding of strengths and areas for improvement.

Based on the quote above, Iyambo acknowledged his access to technology and digital tools which he used to help him in many ways such as assessment and searching for educational materials. So, incorporating technology into education equipped students with the skills necessary for the contemporary job market, where digital literacy and technological proficiency were progressively crucial. The study demonstrates that using technology exposes students to technology, which aids in cultivating skills to apply across diverse career paths.

When asked during the semi-structured interview how technology had assisted him in designing assessment tools (question papers and worksheets), Iyambo acknowledged that he used technology to create assessment tools, especially when graphics and pictures were incorporated and mentioned:

There are pretty good samples of assessment tools on the internet for air conditioning and refrigeration that an instructor can model and contextualise.

The quote highlights that online resources offer useful examples of assessment tools for air conditioning and refrigeration, which Iyambo can adapt and modify to suit his specific teaching context.

Figure 5.13 shows an extract of one of the sample questions that Iyambo used as an example to design his assessment task. This finding emphasises that it is essential that VET teachers engage other sources for samples of assessment tools so that their assessments can be in line with international standards and the skills required for the economy.

ME 405 Refrigeration and Air conditioning

QUESTION BANK

MODULE I

- 1) Briefly explain about the history of Refrigeration?
- 2) Briefly explain about the application of Refrigeration?
- 3) State Clausius statement of second law of thermodynamics
- 4) Explain reversed Carnot cycle
- 5) Explain the working of following
 - a) Heat engine
 - b) Heat pump
 - b) Refrigerator
- 6) Explain about unit of refrigeration
- 7) Explain ideal and Actual reversed Bryton cycle
- 8) Derive the equation for COP of a system working on reversed Brayton cycle (or Bell - Coleman or Joule cycle).
- 9) What are the merits and demerits of air-refrigeration systems?

Figure 5.14: An extract of a question paper from the internet that Iyambo once used as a sample to design his question paper

When asked how VET's ICT training on technology changed pedagogical practices, Iyambo observed a shift in his attitude towards incorporating technology in teaching. He acknowledged feeling more confident in using educational technology in his teaching practices. The VET's ICT training had instilled the belief that integrating technology into his professional life was feasible. Iyambo stated that his pedagogical practices improved so much that he could create a link between technology, pedagogy, and content. He expressed that those lessons after the training had improved drastically as students became more engaging, and he could modify the curriculum to suit varying student needs, contextual factors, and provincial standards. He expressed:

After attending the ICT training, I can see the difference in students' understanding of concepts between my previous teaching methods and the current pedagogical practices. When you thought you knew better, you did not know anything. I cannot believe how teaching has turned out to be as it has improved.

Iyambo reflects above on the noticeable enhancement in students' grasp of concepts following the ICT training. He realised that the old teaching methods were less effective in comparison to the new approaches he now use. Iyambo is surprised by how much teaching has advanced, realising that he was previously unaware of the more effective methods now available.

Iyambo explained that one of the prominent challenges when integrating technology into teaching was a poor and unstable internet connection. Iyambo narrated:

The country's bandwidth is not strong enough, affecting internet connectivity. It usually happens when you least expect it and in the middle of teaching. It is annoying and disturbing when you have planned your lesson and, in the end, it does not go according to plan.

Iyambo's statement above expresses frustration with the country's inadequate internet bandwidth, which often leads to unexpected connectivity issues during lessons. These interruptions disrupt the teaching process and make it difficult to follow through with lesson plans, ultimately impacting the overall effectiveness of the session.

Moreover, Iyambo postulated that institutions does not have an internal policies to guide and direct technology integration in teaching. He followed his instincts and the ways he saw it fit to conduct lessons. Iyambo explained as follows:

Policies serve as a basis for an institution to identify the technological tools and infrastructure to invest in and safeguard TVET teachers in using such tools. The practice would ensure an equitable distribution of technological tools among the TVET teachers.

From the quote above, it is clear that policies play a crucial role in helping institutions choose appropriate technological tools and infrastructure for investment. These policies also provide support for TVET teachers in utilising these tools. By enforcing such policies, institutions can ensure that technological resources are allocated equitably among TVET teachers, fostering equal access to these resources.

The study argues that policies are essential instruments for technology integration. However, the existing TVET policy does not explicitly explain how TVET teachers should integrate technology into teaching.

Iyambo also highlighted technical problems experienced with the technologies, such as troubleshooting and technical issues, which caused disruption and delay when teaching using technology. However, technology seemed to improve students' understanding of the subject matter. Teaching had become easier, and different learning needs were now catered for due to the inclusion of visualisation, demonstration, and images. He acknowledged being hopeful and confident about integrating technology into teaching as the technological era evolved.

5.3.5.6.2 Individual self-initiated learning activities and TPACK development

During the semi-structured interview, Iyambo indicated his focus was on TK, PK, and CK. Iyambo stated that he acquired his CK from the technical trade training at the Zambezi Vocational Institution. He posited that he acquired the TK and PK from the content covered during his studies for a diploma in TVET at NUST. Iyambo explained:

The only challenge I experience is creating the linkages between technological pedagogical content knowledge, which sometimes contributes to the limitation of integrating technology.

Iyambo's statement highlights the difficulty of effectively linking technological pedagogical content knowledge, which can sometimes hinder his ability to fully integrate technology into teaching. This challenge arises from the struggle to create a seamless connection between technology, pedagogy, and content.

Iyambo highlighted that the diploma in TVET was specifically for trainees aspiring to become TVET teachers; hence, it imparted and focused more on pedagogical and TK. The study argues that a TVET teacher must acquire these three areas of expertise as they are critical when imparting knowledge to students.

During the semi-structured interview, Iyambo indicated that he focused on TK the most when using self-initiated learning to learn about technology in VET but also had to include PK and CK as he needed to understand how to select which technologies was suitable for which content and instructional design to avoid creating mismatches between the domains. The self-initiated learning helped Iyambo improve his knowledge and skills, enabling him to integrate technology into teaching. Iyambo explained:

Self-initiated learning helped me enhance my TK, PK, and CK, including my knowledge of using and integrating advanced technologies in teaching and creating an interaction between technology, pedagogy, and content. The interaction between technology, pedagogy, and content allowed me to select suitable technologies and pedagogical practices for relevant content.

The above quote shows that Iyambo recognises the benefits of self-initiated learning in improving their technological, pedagogical, and content knowledge, helping him better integrate advanced technologies into teaching. This understanding of the relationship between technology, pedagogy, and content allows him to select the most suitable tools and strategies for the specific subject matter they are teaching.

Furthermore, Iyambo indicated that he also learned his TK from fellow TVET teachers, especially those who had integrated technology into teaching for quite some time. He stated they would share knowledge, insights, and best practices through their engagements, which he transferred to his classroom teaching. He narrated:

It is motivating when other experienced teachers integrate technology with whom I created platforms to learn and acquire knowledge I did not have. I could incorporate technology into teaching with the knowledge and best practices I acquired. These platforms deepened my understanding of creating an interaction between technology, pedagogy, and content.

Iyambo revealed that they had created a WhatsApp group to meet and discuss technology integration issues affecting them, including the various sources of information and the latest apps to use to obtain the best results in teaching.

Moreover, Iyambo postulated that he had learned some of his TK from students, especially when using apps in his teaching. He narrated that today's students were more technologically advanced than their teachers as they had the advantage of accessing, owning, and using technologies from a tender age. He stated:

These children were born when technology emerged in most countries in Southern Africa. I prefer referring to them as explorers because they would search for things they have never seen or heard before and learn how to do them. They then shared their experiences and feedback on the effectiveness of different technological tools and platforms, which helped me to understand what works best for their learning styles.

The quote describes Iyambo's stance that it seems like he was exploring how students actively engage with new technologies and help shape the understanding of effective teaching tools.

He further encouraged students to create digital content such as videos, podcasts, or blogs related to the subject matter. This not only helped in their understanding of subject concepts but also provided Iyambo with diverse teaching resources. Iyambo also indicated that he had taught in TVET for quite some time and had acquired much teaching experience. He stressed that the teaching experience also contributed to his CK, TK, and PK.

5.3.5.6.3 Drivers and constraints for integrating and using technology in teaching

This section explores the factors that promote or hinder the integration and use of technology in teaching. The section provides a balanced perspective on what facilitates and restricts the meaningful incorporation of technology into educational practices.

During the semi-structured interview, Iyambo was asked to describe his self-initiated learning activities that helped him integrate technology into teaching. Iyambo could not contain his excitement about using technology in teaching. Iyambo posited that formal education was needed but had limitations. He justified: *“That we must learn to undertake what we know when we lack critical knowledge and skills”*. Iyambo explained that when he found a gap in the teaching materials/guides or did not know some aspects of his modules, he engaged the internet and searched for additional information that would make teaching understandable and narrated: *“I watch YouTube videos and engage colleagues in the same field for advice”*.

Iyambo claimed that videos were helpful in that they always provided step-by-step instructions on how to teach a particular topic. They made it easier to follow compared to notes in their study guides. More so, he narrated that presenting visual through videos to the students made teaching and learning interactive as students learnt better through visuals.

He explained that engaging colleagues (TVET teachers) in the same field provided and fostered a supportive environment and allowed for exchanging practical insights. Further, he explained:

When you engage other instructors in the same field, you learn from their success stories of effectively integrating technology into their teaching, highlighting real examples within the institution that can inspire one another and provide concrete examples of the benefits of technology integration.

Iyambo’s remarks highlight the importance of connecting with fellow instructors in the same field to exchange success stories. By sharing practical examples of successfully integrating technology into teaching, instructors can motivate each other and offer tangible proof of the positive impact of technology, encouraging others to implement similar strategies.

The study demonstrates that fellow instructors, especially those integrating technology into teaching, were a great source of knowledge and skills to integrate technology.

Regarding constraints, Iyambo stated that he experienced distractions such as poor internet, and, in the end, he could not perform all the self-learning learning activities, such as watching videos and demonstrating wiring on the refrigerator. He stated:

It frustrates me when I have planned and expected to cover so much from self-learning activities, but in the end, only little or nothing is achieved due to challenges in my way, such as unreliable Internet.

The quote reveals Iyambo’s frustration when planned self-initiated learning activities fall short of expectations. Despite aiming to cover a substantial amount of content, challenges like

unreliable internet connectivity often hinder his progress, resulting in minimal or no achievement of their goals.

Iyambo further stated that understanding and comprehending information from various online sources could be challenging. He explained that the online sources gave so much information that he found filtering only those relevant to him difficult. TVET teachers must be patient and disciplined to achieve their goals.

5.3.5.6.4 Harmonising the support that initiates self-TPACK development

This section presents the support Iyambo believes would help him integrate technology into teaching. When asked during the semi-structured interview about the support he requires to incorporate technology into teaching, Iyambo mentioned needing specific, regular ICT training. He posited that training should emphasise the practical application of relevant technologies in the subject area and teaching methods for effectively incorporating technology to balance content, teaching, and technology use. This implies that many TVET teachers struggle to integrate technology into their instruction due to their training background. The study argues that TVET teachers should be encouraged to incorporate technology once they have received the relevant training tailor-made for their curriculum and unique VET context.

Iyambo recommends establishing dedicated IT support teams for VET institutions. These teams would provide immediate technical assistance to TVET teachers during classes and offer a help desk or online support system for addressing technology-related challenges. According to this study, IT support was essential, as it not only facilitated the training of educators but also provided ongoing assistance for effectively integrating technology into teaching, enabling the teachers to integrate technology into their teaching methods effectively. Consequently, this support enhanced teachers' confidence and skills in using technologies for education.

Iyambo further narrated that VET institutions should establish formal PLCs. These PLCs would enable TVET teachers to collaborate, share insights, and discuss practical ways to integrate technology into teaching. These communities, whether meeting in person or online, served as platforms for TVET educators to explore best practices, confront challenges, and develop innovative strategies for technology-enhanced education. He expressed this issue as follows:

Communities of practice such as PLC are relevant in today's teaching as they enable the TVET teachers to come together and dissect issues about their teaching and overall technology integration. I have benefited so much from such platforms in my career; institutions must formalise and recognise them.

The above quote emphasises the significance of CoP, like Professional Learning Communities (PLCs), in contemporary teaching. These platforms provide TVET teachers with opportunities to collaborate, discuss challenges, and address issues related to teaching and technology integration. Reflecting on the personal benefits gained from being part of such communities, Iyambo stresses the importance of institutions formally recognising and supporting these platforms as essential for professional development.

5.3.5.6.5 Future plans for Iyambo's technology integration

Given Iyambo's remarkable 26-year tenure as a TVET air conditioning and refrigeration teacher and his exemplary role in VET, he predicts his future will revolve around advancing technology integration into this field with a strong foundation in teaching and a keen understanding of the industry.

He admits to continuing learning to contribute further to the modernisation of VET programmes by incorporating innovative technologies and pedagogical approaches. He could involve initiatives such as developing online resources, participating in educational technology forums, or exploring leadership roles within academic institutions. Iyambo's commitment to excellence in vocational education positions him as a key figure in shaping the future landscape of technology integration within the VET sector.

Learning is life-long, so I will embrace every opportunity afforded to me so that I can learn more about technology and its integration into teaching. Technology changes overtime and I need to be prepared.

The above quote indicate that Iyambo's strong desire to continue learning to accommodate changes in technology.

Given Iyambo's 26-year career as an air conditioning and refrigeration TVET teacher, he has established himself as a VET pillar. Determined to move beyond traditional pedagogies, Iyambo plans to implement various initiatives. These include the design of interactive online resources tailored for his subject students, active participation in forums dedicated to educational technology, and pursuing leadership roles within vocational institutions. He sees initiatives that could support his expertise and facilitate progressive changes in technology integration, thereby enriching the learning experience for students. Iyamb's commitment to lifelong learning and constant exploration of modern pedagogical strategies reflect his dedication to fostering excellence in vocational education. He is also planning to review further

his subject's curricula with the industry's evolving demands, ensuring that students are well-equipped for the technological advancements they will encounter in their professional lives.

Looking ahead, one of Iyambo's primary goals is to establish partnerships with technology companies and business communities to sponsor equipment for hands-on training and virtual training. He believes that direct experience with contemporary tools is imperative for student success. In addition, Iyambo intends to spearhead collaborative projects with other VET teachers in the subject area to share best practices in technology usage and curriculum development. It was interesting to note that Iyambo recognised the importance of environmental sustainability. Iyambo aspires to integrate green technologies into the curriculum. He is currently introducing courses on energy-efficient systems and sustainable practices, and he hopes to prepare students for a future where environmental considerations are paramount.

Iyambo's vision extends to the whole VET institution and wishes to develop workshops where educators could exchange insights on technology integration and enhance their instructional skills. According to Iyambo, these workshops aim to build a community of practice that continuously strives for pedagogical innovation. By championing these initiatives, Iyambo will contribute to a transformative shift in VET that will ultimately lead to a technologically adept and environmentally conscious workforce. His continued engagement with both educators and industry experts will undoubtedly make a lasting impact on teaching.

5.3.5.6.6 Summary of Iyambo's case study

A considerable time ago, Iyambo shifted his perception of the instructor's role, transitioning from being a mere provider of information to adopting the role of a guide. Consequently, he places significant importance on allowing students to explore diverse problems using technology within this pedagogical approach. Drawing on his extensive teaching experience, his TPACK evolved gradually, moving beyond traditional PCK by systematically integrating various technologies.

Iyambo has a penchant for incorporating real-life problems and establishing connections between air conditioning and refrigeration and other disciplines such as boilermaker, carpentry, and mechanics. Regarding the use of technology in teaching air conditioning and refrigeration, he believes that computer technology facilitates students in exploring diverse ideas, modelling, and experimenting with different theories. His teaching approach heavily relies on his

pedagogical expertise, leading him to hold high expectations to integrate technology seamlessly and ensure comprehensive coverage of students' instruction from various perspectives.

An analysis of Iyambo's TPACK reveals that content and pedagogy remain his most potent components. While he occasionally exhibits perfectionism by thoroughly understanding a technology before introducing it in the classroom, this approach makes him a late adopter. He prefers to confirm a technology's effectiveness through the experiences of other educators and then dedicate a significant amount of time to mastering every detail of the software. However, when incorporating technology into his teaching, he does so with exceptional accuracy and precision and delivers well-thought-out lessons.

5.3 Findings From the Focus Group Discussion

This section presents the findings from the focus group discussion, which could not be presented under any of the cases because of its collective data and the multiple-case method that the study used.

5.4.1 Technologies for teaching

The focus group discussion revealed that the participants used various emerging technologies for teaching. Participants indicated they use technologies such as LMS, PowerPoint presentations, laptops, android (smartphone), Blackboard, whiteboard, flip chart, and smartboard.

Furthermore, the FGD participants shed light on how they integrated technology into their classroom and what informed such actions/steps. Participants stated that they sometimes intentionally integrated technology into their teaching, though not consistently, as its use depended on the topic. For instance, participants highlighted using technologies such as photocopiers to reproduce study guide materials for students who could not afford copies. In addition, participants revealed that they had set up WhatsApp groups within their different and respective fields with students to facilitate easy communication, enhancing collaboration and accessibility within the class. The participants discussed preparing notes and key points and posting them on the WhatsApp group for the class, so students always had all the content they needed before they attended class.

In addition, participants indicated that they prepared presentations for projects which they projected on overhead projectors and downloaded videos and pictures for visualisation. They also used computers to search for information on YouTube related to topics under discussion on specific days. Participants stressed that technology had improved their teaching, and students understood concepts better because they went through them before the class. The participants emphasised that these technologies helped streamline both teaching and engagement outside the classroom.

The FGD focused on the knowledge of teaching with technology acquired from self-initiated learning and professional development programmes, such as the ICT training and workshops they attended in 2017 and the postgraduate diploma in TVET for some, as what informed participants' integration of technology into teaching. Participants also highlighted that the current teaching era was much informed and dominated by technology and insufficient teaching materials in their field, which prompted them to integrate technology into teaching.

In this section, the findings show that while participants used a broad range of emerging technologies in their teaching practices, integrating these technologies were often selective and dependent on the specific topic. Technologies such as LMS, WhatsApp groups, and multimedia tools like PowerPoint and smartboards were commonly used to enhance communication, collaboration, and student engagement. Technology was seen as beneficial in streamlining teaching, improving student understanding, and providing accessible learning resources outside class time.

The findings further showed that self-initiated learning and professional development shaped participants' approach to using technology in the classroom. Training programmes such as ICT workshops and postgraduate diplomas in TVET have equipped them with the necessary skills to incorporate digital tools effectively. Moreover, the limited availability of traditional teaching materials in their respective fields has further driven the adoption of technology, highlighting its role not only as a pedagogical tool but as a necessity for overcoming resource constraints.

5.4.2 Sources of TPACK

When asked about the TPACK sources they focused on when engaging in self-initiated learning to teach using technology in their context and why, participants highlighted internet sources such as YouTube and educational websites, technologically adept students, and collaboration with their peers in the field to learn from each other's best practices and experiences.

Participants further revealed that the various TPACK constructs (technology, pedagogy and content) were acquired from one or more of the sources, for instance, most participants acquired TK and PK from YouTube videos. For instance, Nadhipite stated:

I use internet sources such as YouTube to learn how to use various technologies to teach my subjects and access information to help me better deliver my lessons. Hence, through YouTube, I was able to pick up some TK and PK which I could not during my pre-service training.

The above quote demonstrate that Nadhipite's reliance on online resources like YouTube to learn how to incorporate different technologies into their teaching and to gather information that improves lesson delivery. By using YouTube, he was able to enhance his TK and PK, filling gaps that were not fully addressed during his pre-service training.

Participants admitted that they acquired most of their CK from the pre-service training they underwent in TVET and other institutions of higher learning. In addition, they narrated that the advanced subject matter which could not be acquired from pre-service training, was then self-learned from either educational websites, peers or YouTube. In this regard, Angula narrated:

I forged good working relationships with fellow TVET teachers especially during the TVET ICT training in 2017. This relationship enables me to engage with fellow teachers on certain issues such as technology integration and even pedagogical practices pertaining to my teaching so that I too can learn from how they are doing it in their classrooms.

Angula's statement above highlights valuable professional relationships built with fellow TVET teachers, especially during the TVET ICT training in 2017. These connections provide opportunities to discuss important topics like technology integration and pedagogical practices. By sharing insights and learning from how others apply these strategies in their classrooms, Iyaloo continues to refine and improve their teaching methods.

During the discussions, participants noted that there had never been a better time for teaching than the present, as students were highly technologically advanced. This provided an opportunity for them to be guided by the students in using technology effectively. Particularly, Shilongo expressed that at times, students assisted him in identifying suitable technologies that were freely accessible online and aligned with the specific concepts and content being taught.

The findings in this section highlight the diverse and dynamic sources through which teachers acquired and developed their TPACK constructs (technological, pedagogical, and content knowledge) in self-initiated learning. Internet platforms, particularly YouTube and educational websites, emerged as critical resources for gaining TK and PK. In addition, collaboration

among peers and technologically adept students played a significant role in enhancing teachers' knowledge and skills. These platforms filled gaps left by pre-service training, equipping teachers with practical skills for integrating technology into their lessons.

5.4.3 Challenges experienced when teaching using technology

Participants were asked to discuss the challenges they experienced when teaching using technology and how they overcame them. The focus group discussion highlighted several challenges TVET teachers faced when integrating technology into their teaching practices. Participants emphasised the absence of clear policies to guide technology integration into VET, underlining the importance of such policies to ensure equitable access and bridge the digital divide. Participants noted that well-defined policies could establish standards for effective technology use in TVET programmes. Specifically, Angula highlighted that the absence of guiding policies created difficulties in integrating relevant technologies to support student learning. He stressed the need for explicit policies detailing teacher access to technologies and resource maintenance. In addition, Iyaloo stated, "*The lack of internal policies or guidelines*", which he believed discourages teachers from adopting technologies in teaching.

Participants equally expressed their dissatisfaction with internet connectivity. They admitted that internet connectivity failed them and made it difficult for them to integrate technology into their classrooms. They emphasised that internet connectivity interruptions disrupted the lesson flow and hindered student engagement and learning.

Notably, Ndangi stated:

I only download and type work or subject content on my laptop and print student handouts. Sometimes, I save the downloaded work on a USB for future use. At least I have access to printing at the institution, which makes it easier for students to get handouts and follow them throughout the teaching process.

Furthermore, Shilongo reported:

I experienced internet connectivity issues when I connected my laptop to show a YouTube video of an engine overhaul in class. The internet started tripping and being unstable, so I had to switch to a traditional explanation and continue with the video the following day.

Along the same line, Nadhipite reflected:

The demand for internet connectivity in the country has increased, and almost every house and institution is connected; however, the supply and efficiency do not correspond with the technical support provided by the service provider. TVET teachers need stable and regular connectivity

for effective teaching and learning. It isn't comforting when you are busy and in the middle of teaching using technology, for example, playing a YouTube video with students, and just before you know it, it abruptly stops playing. It is confusing because when it eventually resumes, it becomes difficult for students to follow again.

From the above excerpts, it can be highlighted that laptops were the dominant technology highly used for downloading, typing, and printing subject content, allowing students to have handouts for better references during lessons. Participants also stored downloaded materials on a USB for future use. While the availability of printing facilities at most of the institutions supports lesson preparation, unreliable internet connectivity remains a significant challenge.

During one lesson, Iyaloo attempted to show a YouTube video of an engine overhaul, but an unstable internet connection interrupted the session. Consequently, they had to resort to a traditional explanation and postpone the video until the next day. Iyaloo notes that although internet demand has increased— with many households and institutions now connected— the supply and efficiency have not kept pace with the technical support provided by service providers. They stress the importance of a stable and consistent internet connection for effective TVET teaching and learning. Interruptions, such as a YouTube video unexpectedly stopping mid-lesson, create confusion and make it difficult for students to re-engage with the content once the connection resumes.

Moreover, participants indicated they experienced technical problems with technologies, especially laptops. They further revealed that they were more worried and annoyed by spending more time setting up the technologies to use. In addition, they admitted that when using technology in teaching, challenges such as technical glitches, software bugs, and all sorts of problems like freezing, slow operation, and troubleshooting issues that always affected technological tools existed. However, there were no dedicated ICT personnel to offer help and support at the institutions when faced with technical problems such as troubleshooting and software bugs. He further explained that technical issues also hampered teaching as most VET teachers did not have the skills to solve them, especially troubleshooting.

For instance, Ndangi explained:

There was this one time when I tried to show students a video on sustainable farming practices in a developed country, but then the laptop started freezing and taking too long to load, wasting more lesson time.

The above quote demonstrate Ndangi's experience where he tried to show students a video on sustainable farming practices in a developed country. However, the lesson was disrupted due

to technical issues, as the laptop froze and took too long to load. This delay wasted valuable class time and interfered with the effective delivery of the lesson.

Another challenge that participants highlighted was the inadequate technological infrastructure. They acknowledged that they were willing to use and integrate technology into classrooms, but resources were not available to implement such plans fully. Specifically, Angola posited:

Insufficient infrastructure, such as outdated hardware, limited internet bandwidth, or a lack of sophisticated software, impeded the successful integration of technology in classrooms.

Angola's remarks above emphasises that inadequate infrastructure, including outdated hardware, restricted internet bandwidth, and a lack of advanced software, poses major obstacles to the successful integration of technology in classrooms. These limitations disrupt the smooth implementation of digital tools, ultimately affecting the effectiveness of technology-driven teaching and learning.

Participants also admitted that technology was a double-edged sword in the classroom, as it could distract students if not used appropriately. Sometimes, students did not concentrate on the message or teaching delivered through a video but on photos, appearance, or music playing in the background. Angola indicated that the disturbances were even worse when students used their technologies in the teaching and learning process, as it tempted students to shift focus from education-related content. For instance, he expressed:

When I was teaching vehicle diagnostics and showing a video, students concentrated more on the music in the background and did not focus on what was said. This case was a complete turnoff; therefore, setting guidelines for technology integration would help.

The quote above indicate that Angola recalls an experience during a vehicle diagnostics lesson where a video was shown, but students became distracted by the background music rather than paying attention to the video's content. This caused a negative learning experience. To avoid such distractions in the future, Angola argues that implementing clear guidelines for using technology, ensuring students stay engaged with the educational material is critical.

The findings in this section show that while technology offers significant benefits for TVET teaching, the challenges related to policy, infrastructure, connectivity, technical support, and student engagement must be addressed. A more supportive and structured approach, including transparent policies, better infrastructure, and reliable technical assistance, would enable

teachers to fully leverage the potential of technology in enhancing the teaching and learning experience.

5.4.4 Support needed to integrate technology into teaching

During the focus group discussion, participants were prompted to state the support required to integrate technology. In addition, they were asked to indicate why they needed it and where it would come from. Participants acknowledged that regular workshops and training covering technological, pedagogical, and content aspects must be provided and were considered critical for developing knowledge to enhance technology integration. This was because the current workshops and training only focused on basic computer operation skills on Microsoft Office packages such as Word and Excel. The participants highlighted that the NTA and the MHETI needed to coordinate the workshops and training. For instance, Iyambo stated:

TVET teachers needed specific, regular ICT training. The training should emphasise the practical application of relevant technological tools in the subject area and teaching methods for effectively incorporating technology to balance content, teaching, and technology use.

The participants believed that these workshops and training would serve as refresher courses for them to refine their PCK, integrate technology into teaching, and then develop TPACK.

Participants such as Ndangi and Nadhipite called for the transfer of TVET teachers in exchange programmes to developed nations with well-established TVET systems to learn and understand the best practices for integrating technology in teaching. They believed this would enable them to gain international exposure and benchmarking to provide them with global best practices and strategies for improvement while enhancing collaboration.

These findings show that although participants were integrating technology into teaching, they did so without the much-needed support. The findings further reveal that TVET teachers must be supported in integrating technology into education, especially with regular training and workshops. While TVET teachers are already incorporating technology into their teaching, the lack of adequate support in terms of training, resources, and international exposure remains a significant barrier to maximising the potential of technology in education. Therefore, it is clear that a more robust and comprehensive support system, including regular professional development, cross-border learning opportunities, and stronger institutional coordination, is essential to empower TVET teachers to integrate technology effectively and sustainably into their teaching practices.

5.4 Chapter Summary

This chapter presented the study findings from the questionnaire, semi-structured interviews, non-participatory classroom observation, and focus group discussions. Most participants acknowledged limited knowledge about TPACK; however, they had acquired the TPCK from various sources such as pre-service training, self-initiated learning, students, peer engagement, and online sources such as YouTube. The participants also acknowledged that their limited understanding of TPACK was attributed to its new concept and form of knowledge in TVET. Moreover, the participants had access to different technologies, such as laptops and smartphones, and those provided by their institutions, such as Blackboard, overhead projector, and whiteboard, making it easier to use and integrate technology into teaching.

Moreover, participants highlighted reasons for using and integrating technology into teaching, including preparing teaching and learning materials, making teaching presentations, and enabling students to work collaboratively. The participants underscored the importance of preparing teaching and learning materials, which was currently a concern in TVET. Participants admitted integrating technology into education benefits students and TVET teachers. The participants revealed that teaching had become more fun, interactive, and engaging than the traditional way that they were accustomed to. Technology has also made teaching more manageable and flexible to accommodate students' learning needs and styles. Participants also indicated that their pedagogical practices changed after they attended the VET's ICT training to the point that they held different perspectives towards teaching and became innovative in delivering their lessons.

Participants also postulated how technology had supported and contributed to how they designed assessment tools. Notably, technology has made it easier to design assessment tools such as multiple-choice questions using Google Forms, creating marking grids, and even marking online.

Although participants acknowledged incorporating technology into teaching, they faced significant challenges, such as limited knowledge of operating technologies, technical problems with technologies, and unstable internet connectivity. Participants then highlighted the need for professional development programmes such as workshops, conferences, and seminars to acquire advanced skills and refresh their redundant skills.

CHAPTER SIX

DISCUSSIONS OF FINDINGS

6.1 Introduction

The previous chapter presented the results of the study's questionnaire, semi-structured interviews, non-participatory observations, and focus group discussions. The results were presented based on the research questions to which the study aimed to provide answers and aligned to the theoretical frameworks. This chapter aims to discuss and analyse VET teachers' TPACK and examine how self-initiated learning activities of technologies enhanced their TPACK development.

The chapter outlines these sections: Section 6.2 presents the study's approach and Section 6.3 discusses the key findings of the research objectives. The chapter concludes with the proposed TPACK framework for the VET context.

6.2 The Approach in This Study

This study addresses a critical gap in research on technology integration and the development of TPACK in Namibia's VET context. While existing literature has primarily focused on primary, secondary, and pre-service teacher education in developed countries, this research shifts the focus to VET in Namibia, a developing country. By doing so, it becomes the first of its kind to explore the unique challenges and perspectives of Namibian TVET teachers. The study offers a novel contribution by proposing a framework for TPACK tailored to the VET context, marking a significant step towards bridging the research gap in this area.

Adopting a qualitative multi-case approach, the study deeply explores the self-reported methods, practices, and experiences of TVET teachers concerning TPACK. This methodological choice deviates from the quantitative and single case approaches prevalent in earlier TPACK research, enabling a more nuanced understanding of technology integration's contextual and individualised dynamics in vocational education. Investigating TVET teachers' perceptions and experiences provides rich insights into how TPACK develops contextually within Namibia's VET sector.

The research highlights five foundational premises. First, it addresses the scarcity of TPACK studies involving TVET teachers, particularly in developing countries. Second, it situates its investigation within the developing world, offering perspectives that challenge and complement the predominantly developed-world-centric TPACK literature. Third, it emphasises the VET context, which has been largely overlooked in global TPACK research. Fourth, it identifies the need for context-sensitive and practice-oriented frameworks, filling a gap in understanding how VET teachers develop and apply TPACK. Lastly, the study's qualitative approach enriches the field by uncovering intricate, context-specific insights that quantitative methods might overlook.

Therefore, this research lays the groundwork for understanding and advancing technology integration and TPACK in Namibia's VET sector. It fills a significant gap in the literature and offers practical implications for improving vocational education through technology-enhanced teaching practices.

6.3 Key Findings from the Study

Technology integration and TPACK development in VET are essential for preparing students with the practical skills and knowledge required in today's workforce. Hence, TVET teachers are crucial in navigating the intersection of content, pedagogy, and technology to create meaningful and impactful learning experiences in vocational settings. The key findings were discussed with the specific research objectives in mind and aligned with the literature and theoretical frameworks. The research objectives were:

- To understand the TVET teachers' self-reported descriptions of their TPCK in VET.
- To discover the sources of TPCK the TVET teachers draw upon during self-initiated learning of integrating technology in the classroom.
- To find self-initiated learning activities that support and constrain TVET teachers in integrating technology into teaching and TPACK development.
- To explore the support TVET teachers need to integrate technology into teaching and develop TPACK.

To provide answers to the research objectives in alignment with the literature and theoretical frameworks, I organised my discussions on TVET teachers' technology integration and TPACK development around the following central themes identified during data analysis:

- The individual understanding and shifting of TPCK understanding.
- Individual self-initiated learning activities and TPACK development.
- Drivers and constraints for technology integration and use of technology in teaching.
- Harmonising the support that initiates self-TPACK development.

6.3.1 The individual understanding and shifting of TPACK understanding

This central theme captures the core of TPACK by highlighting the necessity for a dynamic synthesis in educational approaches. The theme focuses on the idea that effective teaching and learning result from the dynamic interplay and adaptation of TPACK. Researchers have mentioned that TPACK describes a TVET teacher's knowledge on how to implement effective pedagogy and present content in a technology-enhanced learning environment (Fahadi & Khan, 2022). Each teaching scenario in the present study intersected these domains in diverse manners. The primary components, including content, pedagogy, and technology skills, were effectively cultivated and engaged with one another in customised and unique ways. Individual contexts and the TVET teachers' prior experiences with technology shaped the interactions (Tay et al., 2021).

The study findings revealed a general ambiguity in the description and understanding of TPCK by the participants (TVET teachers). This finding agrees with Thohir et al.'s (2022) and Munasinghe et al.'s (2021) studies, where teachers found defining TPACK in their practices as a concept and a form of knowledge challenging. The study argues that this ambiguity could be due to several personal and institutional attributes, such as TVET teachers not being aware of TPACK, lack of TPACK studies within VET, and limited professional development programmes which could expose these TVET teachers to TPACK. However, the significance of this finding lies in its contribution to understanding TPACK development trends in under-researched TVET contexts. Gaining insights from these TVET settings is crucial for understanding how TPACK concepts are adopted and tailored to different educational environments. Furthermore, the findings resonate with Arifin et al. (2020), who highlight that studies on the TPACK concept emphasise the concept's appropriateness but must be tailored to specific fields of context, underscoring the need for TPACK to evolve within the context of vocational education. Therefore, by including TVET perspectives, this study enhances the overall relevance and adaptability of TPACK frameworks across a broader range of teaching scenarios.

Nonetheless, the consistently limited TPCK and understanding among TVET teachers raises concerns about when they would achieve understanding in these areas. Thus, the study argues that not all TVET teachers possess a similar description or understanding of TPCK despite participating in ICT-related training or teacher professional development programmes. For instance, all participants except Iyambo did not understand TPACK. Iyambo was aware of TPACK and more oriented to technology, which led to him selecting the correct definition among all the VET teachers.

Another finding of the present study is that despite the limited description and understanding of TPACK by some TVET teachers, technology integration is happening in the classrooms. The finding contrasts with Rahmawati et al. (2021) and Chan and Mohammad (2019), who found that proficiency in TPACK, precisely ICT skills, continues to impact technology integration into teaching and learning. However, studies by Tanak (2020), Getenet (2017) and Pamuk (2012) reinforce the finding that teachers need to develop TPACK as a prerequisite to integrating technology into their teaching practices effectively. The TVET teachers have acknowledged creating a balance in the interaction between technology, pedagogy, and content. The study reveals that the selected TVET teachers have been integrating technology using knowledge acquired from self-initiated learning activities, collaboration with fellow VET teachers, feedback from their students, and insights from their teaching experiences. The finding aligns with Jossberger et al. (2020) that self-initiated learning activities are flexible and are professional development approaches that enhance the incorporation of technology into teaching. This understanding is critical for TVET teachers as it allows them to employ technological resources in their instruction effectively. Enhanced technological fluency combined with pedagogical strategies equips teachers to facilitate learning in more engaging and effective ways.

The TVET teacher experts in these areas can tailor their use of technology to complement specific content areas, thus enriching the learning experience. The study reveals that technology integration is influenced not only by TPACK understanding but also by TK and access to technologies. This finding aligns with Dalal et al.'s (2017) view that empowering TVET teachers for successful technology integration does not necessarily require them to be specifically familiar with the TPACK framework. Instead, the TPACK framework emphasises that TVET teachers should rather grasp how to weave instructional approaches wherein technological, content, and PK are intertwined. The study suggests that these TVET teachers

may have integrated technology while unconsciously developing specialised TPACK related to teaching in their context.

TVET teachers, in their justifications, described TPACK as a new concept and form of knowledge, especially in the VET context, which informs limited knowledge and understanding. The justification aligns with Nepembe and Simuja's (2023, p. 94) study on instructors' perspectives of TPACK in a vocational training classroom in Namibia. They noted that TPACK and its associated practices are not employed in examining VET instructors' practices in Namibia. Similarly, Olayinka et al.'s (2023) study on promoting pre-service teachers' TPACK development in an education science course found that TPACK as a concept and form of teacher knowledge is new, while Koehler et al.'s (2014) study on the TPACK framework found that TPACK is a relatively new framework influencing teacher education theory, research, and practice.

Overall, this study suggests that the different ways of describing the TPACK by TVET teachers can be attributed to the inconsistencies in their pre-service training and personal, professional development programmes (Luik et al., 2018) as some TVET teachers had no prior training on teaching which was supposed to equip them with content and PK.

The TVET teachers recognised factors influencing their understanding of TPACK, including its novelty, unfamiliar acronyms, and the limited focus on technology integration into the VET sector. Further, the TVET teachers acknowledged the opportunities they derive from becoming aware of TPACK and the position it places them in terms of technology integration. These opportunities could enable them to actively seek various methods to flexibly adjust to technological changes and view them as opportunities rather than challenges.

Regarding where on **Figure 5.4** participants would place their TPACK, the study findings indicate that the teachers place their knowledge constructs differently within the TPACK diagram based on the TPACK TVET teachers have acquired and possess. The study reveals that some TVET teachers prioritise their TPACK components in the order of content, pedagogical and technical knowledge, others prioritise them depending on which one they are competent in and some confidently identify their TPACK with TCK and PCK. This variation suggests that the TVET context significantly influences how VET teachers structure their TPACK. For example, Shilongo's strong subject knowledge and pedagogy led him to place his TPACK on content and PK, while Ndangi was more content-oriented on horticulture and crop production and did not receive training in pedagogy, so he only related his TPACK to CK. The

finding supports Zhubi and Ismajli's (2022) study that analysed the relationship between TPACK in primary school teachers' lesson planning. Their study found that integrating technology into the teaching process extends beyond merely applying TK; it also necessitates a deeper understanding of the intricate connections between pedagogy and teaching content. Other studies, such as those by Tan et al. (2021), Huang and Lajoie (2021) and Grimus (2020), emphasise that integrating technology into teaching involves more than just acquiring TK. It requires a deep understanding of the complex interplay between pedagogy and instructional content. The study argues that only some TVET teachers would place their TPACK on technological and PCK. These teachers struggle to effectively connect technology, teaching methods, and subject matter. This disconnect hampers their ability to choose appropriate technological tools for teaching content. The study's findings also show that TPCK may have allowed TVET teachers to incorporate technology into teaching, necessitating a thorough comprehension of the reciprocal connections between pedagogy and subject content. This finding corresponds to the TPACK framework's narratives by Koehler and Mishra (2009), which state that the interactions between technology pedagogy and technology allow teachers to realise more innovative processes in teaching and learning.

Despite some of the TVET teachers being trained as VET students and teachers during the era that has experienced using technology in teaching in some HEIs, the participants in this study could not relate the complex relation between technology, pedagogy, and content. Consequently, it is unsurprising that these teachers would feel unprepared to integrate technology into their teaching methods, often overlooking its importance and relevance in education. This finding concurs with the results of some studies by Evens et al. (2018), Jang and Tsai (2013), Yeh et al. (2014), and Tseng et al. (2022).

Further, the findings correspond to Kern et al. (2023) and Andersson (2022), who indicate that most VET teachers are hired primarily based on their practical expertise but lack formal pedagogical training. Likewise, TVET teachers frequently receive on-the-job training from their respective TVET institutions, which means they may lack formal instruction in practical skills such as welding or carpentry and professional skills like effective communication and time management. The findings align with Tyler et al.'s (2021) study on constructing a professional identity in VET from a teacher's perspective. Their study found that most VET instructors, possessing extensive expertise in a specific trade or profession, are frequently employed in VET. It is argued in this study that the teachers also bring familiarity with the tools and technology used in that industry. Literature has indicated that as proficient

professionals, VET instructors should possess an advanced pedagogical repertoire beyond the traditional transmissive educational paradigm (Al-Harbi & Ahmad, 2022; Anselmann, 2023; Kolb, 2021). Likewise, the finding strengthens the narrative of the TPACK framework that teachers must possess profound insights into each of the knowledge components of TPACK to effectively integrate and synchronise technology, pedagogy, and content into their teaching (Koehler et al., 2014).

In contrast, the above findings are inconsistent with Zhubi and Ismajli's (2022) study that analyses the relationship between technological and PK and the content of primary school teachers. The study results reveal that PK surpassed content and technological expertise to a notable extent. The discrepancy with Zhubi and Ismajli's (2022) findings can be attributed to variations in teaching roles, educational frameworks, professional training priorities, availability of technology, and research methods. While their study highlights the predominance of pedagogical knowledge (PK) among primary school teachers, this trend may not be applicable in other contexts where greater emphasis is placed on content knowledge or technological proficiency. However, TVET teachers in this study acknowledge that their PK was acquired only when they enrolled for different courses, such as the diploma in TVET and through self-initiated learning in their subject areas. The findings show that CK is more prominent than pedagogical and technology knowledge among VET teachers as they were trained through VET programmes that aimed to offer industry-related technical skills. This finding corresponds with Shi and Jiang's (2022) study investigating how EFL teachers perceive and self-evaluate knowledge of content, pedagogy and technology, the interplay of these with each other (TPACK), and the underlying influential factors for TPACK construction. The study's findings indicate that the teachers' self-assessment of their TPACK revealed that they were highly confident in their CK, PK and PCK. However, their confidence was noticeably lower when integrating technology despite regularly incorporating it into their teaching. The study's results show that several TVET teachers incorporated technology into their teaching early in their careers. This can be attributed to two key reasons. Firstly, as technology is a fundamental part of daily life, educators have adapted accordingly. Secondly, vocational and technical education inherently demands the use of technology due to the technical nature of the subjects taught.

In terms of the technological tools used for teaching and learning, the findings show that TVET teachers use innumerable technological devices, whether their own or those provided by the TVET institutions where they teach. Specifically, TVET teachers use and incorporate in their

teaching technological tools, including the LMS, a whiteboard, Blackboard, flip charts, overhead projectors, android (smartphone), laptops, Internet, social media, visuals, videos, and various technologies (machines and equipment) commonly in the VET technical subject's curriculum. However, while some teachers use Blackboard effectively, others struggle with basic tasks such as downloading videos, as well as more advanced tools like overhead projectors and learning management systems (LMS). This suggests that teachers' use of technology largely depends on their level of proficiency, which in many cases has hindered effective technology integration. The findings concur with Stoilescu (2011), who found that educators employ various technologies within classrooms, including graphic calculators, computers, Blackboards, video projectors, internet services, and manipulatives. However, in the present study, Blackboard, android/smartphones, overhead projectors, and laptops dominate the technological tools used by most TVET teachers. The study reveals that androids/smartphones and laptops are commonly accessible and affordable compared to other technological devices available in an institution. The findings agree with Kouser and Majid's (2021) study, which provides information about various technological tools that help enhance teaching and learning. They found that smartphones and laptops have become an integral component of the teaching–learning process.

Similarly, intelligent mobile devices have become abundant in schools and have been reshaping educational approaches across various age groups and academic levels, impacting nearly worldwide communities (Kalogiannakis & Papadakis, 2020). Interestingly, the findings reveal that TVET teachers use these technological tools differently based on their accessibility and individual TVET teachers' needs. This finding aligns with Grájeda et al.'s (2024) study, which examines the adoption and impact of Artificial Intelligence tools in higher education at a private university in Latin America, further reinforcing their conclusions about the challenges and potential of Artificial Intelligence integration into academic settings.

The results indicate that despite the varied applications of technological tools, educators adeptly adjust them, aligning with the curriculum requirements, teachers' pedagogical practices, and students' learning styles. It is worth mentioning that although TVET teachers use various technological tools, some have acknowledged their lack of proficiency and competencies. For instance, tasks such as downloading YouTube videos posed challenges to Nadhipite. Also, TVET teachers admitted that the VET's ICT training they attended offered them only basic computer operation skills on Microsoft Office packages such as Word and Excel and did not adequately cover pedagogical practices as they were expected. It is argued

in this study that training TVET teachers in basic computer operation skills would not equip them with the knowledge to integrate technology into teaching. Nevertheless, this unexpected experience did not prevent these TVET teachers from learning to integrate technology as they undertook self-initiated learning activities to understand technologies and share their knowledge.

Regarding the rationale for using and integrating technology, the present study reveals that TVET teachers use and integrate technology in teaching for various reasons depending on a specific case and unique context. The most highlighted reasons are to prepare educational materials, make teaching presentations, search for information, and allow students to work collaboratively. The study suggests that using technological tools like the internet allows TVET teachers to access unlimited information about their field. Further, the information obtained from online sources is usually detailed and precise compared to what may have been made available to them through teaching guides. The study argues that TVET teachers use information from different sources using technologies that allow them to become creative and find innovative ways to present it to the students. This finding supports Sekhri's (2021) study that describes the theoretical frameworks and current trends in ICT used in research exploring science education, teacher training, professional development, and ICT integration. The study results indicate that ICT enables collaboration among researchers worldwide, enhances teaching and learning quality, aids curriculum design and skill development, and improves student focus, communication, motivation, and creativity. Furthermore, the findings correlate to Pinto and Leite's (2020) study, which found that teachers primarily used LMSs to enhance access to information and learning materials.

The study suggests that integrating technology into teaching can foster a deeper understanding of the subject matter and make learning more enjoyable and effective. The study argues that when TVET teachers use technology to make teaching presentations, it becomes easier to present concrete abstracts, encouraging interactions between them and the students. Ciriello et al. (2024) and Dawani (2023) assert that, as an example, TVET teachers can employ Microsoft PowerPoint to present a topic creatively and innovatively, facilitating subsequent discussions and the exchange of ideas and thoughts. It is worth noting that presentations are usually shortened in slides, highlighting only the main points, leaving students desiring more explanation and evoking questions throughout the lesson. Kumi-Yeboah et al. (2020) explored digital technologies that promote educational experiences and achievements of culturally diverse learners via interviews with 46 culturally and linguistically diverse students across

different academic programmes. The findings reveal that participants used digital technologies to interact with LMSs to actively engage and contribute to knowledge creation, aiming to enhance academic performance online. In addition, Tuma (2021) highlights that educators can effectively use new technologies to transform learning activities into personalised, interactive, and collaborative experiences.

It is worth mentioning that TVET teachers need to be mindful of students' different learning needs and styles so that they can prepare their lessons accordingly. Hence, some TVET teachers prefer using technology to prepare educational materials that students can take home to learn at their own time and pace. Students engaging with educational materials can enhance their understanding of concepts, similar to a classroom setting, but without time constraints.

Some TVET teachers have gone out of their way to engage with various technologies that contribute to interactions and increase student productivity. This finding aligns with those of and Hossain (2023) and Shevira (2023), who stated that using technology for teaching and learning provides a range of educational materials, such as educational videos, simulations, data storage, database use, mind-mapping, guided discovery, brainstorming, music, and the World Wide Web. Particularly, Shevira's (2023) study suggests that approaches include using Open Education Resources such as teaching materials from websites and video streaming, leveraging social networks for networking opportunities, and using smartphones to access online information contribute to a more enriching and enriching learning experience. For example, Shilongo indicates that using Blackboard allows students to interact with the content. The communication tools that LMSs provide allow the TVET teachers to interact with the students and among students. The study notes that these platforms foster community and encourage active student participation.

Moreover, the study findings also reveal that these technological tools effectively assist TVET teachers in designing assessment tools. Hence, TVET teachers use technological tools to assist them in designing assessment tasks and monitoring student performance and knowledge construction. The study suggests that technological tools simplify and fast-track the assessment process and the feedback loop when used to design assessment tools. The assessment process and feedback loop thus encourage students to do more and improve their performance. The findings support prior research that using technology to design assessment tools saves instructors time and effort, confirming the findings of Birkeland (2022) and Robertson et al. (2019). Specifically, Robertson et al. (2019), who studied using technological tools for

formative assessment, found that online faculty members save time and effort by using quiz scores. However, the study suggests that Web 2.0 tools not only aid students in preparing for summative assessments but also have the potential to impact participation, the time students wait for feedback, and the time teachers spend grading, particularly when selected thoughtfully. Morris et al. (2021) also state that providing prompt feedback throughout the formative assessment to enhance student performance is essential in learning and teaching.

The present study also found that most TVET teachers did not receive training on designing assessment tools, especially using software apart from Google and YouTube, except Iyaloo. The finding is congruent with the reviewed literature (Abduh, 2021; Dayal, 2023; Joshi et al., 2021) that most TVET teachers lack adequate training to carry out and design assessment tools online. The current study argues that due to the lack of training in using technology to design assessment tools, TVET teachers use traditional methods, such as short answers and essays, which are manually created. The literature also highlights a significant lack of readiness among teachers and higher education institutions to implement assessment approaches tailored to digital environments. The findings indicate that Iyaloo uses Blackboard to design assessment tools. It is worth noting that despite using Blackboard to design assessment tools, Iyaloo has also transferred the skills of developing them to fellow TVET teachers. The findings align with Almutairi and Elsayy (2023), who state that most faculty members and students favour using Blackboard for assessments. In addition, faculty members are familiar with the assessment tools available on Blackboard and feel confident using them. However, they believe that challenges are associated with technical problems, and some EFL students have reported difficulties with the essay tests on Blackboard.

The current study also found diverging reactions to how the VET's ICT training changed the approach to the pedagogical practices of TVET teachers. Five cases indicated that their pedagogical practices have been transformed, making it easy and flexible and increasing student participation. From the findings above, TVET teachers acknowledged during the focus group discussion the potential of the VET ICT training and how it shaped their pedagogical practices. Their approaches changed and enhanced their confidence in incorporating technology into teaching. The findings align with Goh and Sigala's (2020) study, which examines the factors that hinder university academics from integrating new ICT into their teaching methods and explores strategies for addressing these challenges. Their study findings reveal that ICT training significantly enhances pedagogical practices by enabling teachers to integrate technology into their teaching, adopt diverse instructional strategies, and foster a more

engaging and collaborative learning environment. The study suggests that ICT training and workshops are helpful as they assist in shaping TVET teachers' practices for the better. However, some TVET teachers were not happy with the ICT training provided. For instance, Shilongo was unsatisfied with the VET ICT training because he felt it did not cover how to teach using technology in his field. Therefore, Shilongo undertook self-initiated learning, which changed his pedagogical practices. The findings concur with Smith and Gillespie (2023) that most professional development programmes that teachers participate in consist of traditional workshops that seldom alter teaching practices and generally do not improve student achievement. The study suggests that despite the ICT training provided, TVET teachers can also self-initiate learning new technologies and use them in their pedagogical practices. Therefore, innovative and creative ways of doing things improve and update TVET teachers' teaching practices. The TVET teachers' ability to learn new technologies independently can be understood through this study's SDL theory (Knowles, 1975), emphasising increased independence and learning outside the formal environment.

Regarding technology integration, the study found that TVET teachers face challenges and obstacles when using technology in teaching. TVET teachers mentioned various challenges they encounter when using technology, malfunctioning technological devices such as lack of internet connection, insufficient time to prepare the technological tool and continue teaching, poor internet connection, lack of appropriate subject software, and lack of policies to guide and support technology integration. The findings converge with those of other researchers, such as Exmeyer and Hall (2023), Francom (2020), and Liu et al. (2024), indicating that research has identified the inadequacy of both physical and technological infrastructure as a crucial barrier to successful integration. Moreover, parallel to internet connectivity problems, Hossain's (2023) study on technology integration challenges in teacher education reveals that technical problems such as poor connectivity, virus attacks, and printer malfunctions pose significant obstacles for teachers. The study notes that once students and TVET teachers are frustrated by technological and technical challenges, the entire teaching and learning process becomes a cause for concern and may lead to TVET teachers being deterred from using computers due to fear of potential equipment failures. Nadhipite and Shilongo's responses revealed that challenges such as a lack of dedicated ICT personnel, policies, and digital literacy skills hinder technology integration among TVET teachers. The current study results align with Francom's (2020) study examining teachers' perceptions of how barriers to technology integration change over time and how barriers may not be the same in different settings, including small and large

school districts. His study mainly found that time constraints remain the primary and enduring obstacle to technology integration. Also, while there was an increase in access to technological tools and resources, there was a decline in teacher beliefs as well as in training and technical support.

Furthermore, the research attributes the challenges of technology integration to perceived obstacles such as inadequate in-service and pre-service training, limited content support, and the absence of an effective incentive system. The study suggests that TVET teachers must be aware of the challenges related to integrating technology and should be supported in addressing them. Therefore, TVET teachers should examine, identify, and address technology integration challenges with practical solutions to achieve a successful, efficient, and productive implementation of educational technology. The study suggests that TVET teachers and centres should have access to an environment where technologies seamlessly collaborate to ensure that technological challenges do not impede the instructional process.

6.3.2 Individual self-initiated learning activities and TPACK development

Regarding the sources of knowledge domains related to TPACK that TVET teachers draw upon during self-initiated learning on technologies, the findings show that TVET teachers were involved in self-initiated learning activities that enabled them to develop knowledge domains related to TPACK. It is evident from the findings that some TVET teachers drew their knowledge domains associated with TPACK from pre-service training, others from professional development programmes such as workshops, seminars, and training, while others from prior experience in teaching, colleagues in the same field, TVET teachers–student collaboration, collaborative learning communities, and internet sources such as YouTube. This finding supports Zhang and Tang’s (2021) study on offering a general understanding of current teachers’ TPACK study in China using statistics and content analyses. The study results indicate that some teachers drew their TPACK through pre-service enrolled method courses such as microteaching lessons. Shafie et al. (2019) suggest that educators can proactively enhance their TPACK and create a more innovative and effective learning environment for their students. The sources of TPACK TVET teachers draw upon during self-initiated learning are presented below in no particular order in Table 6.1.

Table 6.1: Major sources of TVET teachers' TPACK

TPACK Components	TPACK Sources

Content Knowledge	• Pre-service training • Teaching knowledge and experience • Collaborative learning communities
Pedagogical Knowledge	• Pre-service training • Self-initiated learning • Teaching knowledge and experience • Collaborative learning communities
Technological Knowledge	• Technology-related training • Self-initiated learning • Collaborative learning communities • TVET teacher-student collaborative effort • Internet sources
Technological Pedagogical Knowledge	• Collaborative learning communities
Technological Pedagogical Content Knowledge	• TVET teacher-student collaborative effort

6.3.2.1 Content Knowledge

This section discusses the sources from which TVET teachers obtained the CK domain related to TPACK during their self-initiated learning to integrate technology into teaching. It is worth noting that pre-service training, prior knowledge and experience, collaborative learning communities, and the internet emerged as pillars of CK development.

- **Pre-service training**

Although pre-service training might be assumed to be the sole source of CK and PK, the analysis of interview findings suggests otherwise. The study indicates that all TVET teachers underwent pre-service training, which equipped them with essential CK. However, some TVET teachers, particularly those who did not receive formal teaching training, were unable to acquire PK through their pre-service training. The interview narrative reveals that some TVET teachers attained undergraduate and postgraduate qualifications while others only completed VET.

Pre-service training is the initial training that TVET teachers undergo facilitated by the responsible institutions they are enrolled at, such as TVET, universities, and colleges. The

finding supports Durdu and Dag's (2017) study on pre-service teachers' TPACK development and analyses of their conceptions of learning and teaching with technology. The study suggests that pre-service training prepares and equips TVET teachers with CK. However, the findings contradict Gill and Dalgarno's (2017) study on developing six Australian pre-service teachers' TPACK through a series of six semi-structured interviews throughout their four-year teacher preparation programme, revealing similar results. They argue that the extent of ICT use during professional placement, expectations and practices of supervising teachers, school culture, and available resources influenced teachers' TPACK development. Further, the implemented instructional processes positively affected pre-service teachers' TPACK development. The study recommends implementing more courses requiring pre-service teachers to develop computer-based instructional materials and use their materials with microteaching sessions. This finding is underscored by Mishra and Koehler (2006), who state that CK, as one of the knowledge domains of the TPACK framework, is essential for teachers.

Notably, the TPACK framework underscores that prospective teacher candidates, for instance, generally start with limited proficiency in all the knowledge domains related to TPACK, indicating the absence of an inherent knowledge foundation for further development in comparison to in-service training teachers (Koehler et al., 2014). The lack of intrinsic knowledge is also true for the present study, as TVET teachers only had limited proficiency from secondary education before their pre-service training (Hauuanga, 2023). The study suggests that drawing their CK from pre-service training enabled TVET teachers to be better positioned and equipped to develop TPACK.

The study further found that during pre-service training, TVET teachers participate in various aspects of university preparation, such as ICT-focused subjects, assignments, and lecturer modelling, which contribute to the growth of TPACK. Consequently, the teachers have commonly completed assignments and participated in teaching modelling, particularly during their teaching practice in educational courses. This finding concurs with Santos and Castro (2021) that most teachers acquire their CK from pre-service training. The study clearly illustrates how pre-service teachers effectively applied their learning from the College of Education at Bulacan State University. The pre-service teachers exhibit strong knowledge across all areas of TPACK, with the highest general mean observed in CK (3.75).

- **Teaching knowledge and experience**

Furthermore, TVET teachers indicated that teaching knowledge and experience have influenced their CK. The teaching knowledge and experience are assumed to have been gained from the teaching practice and apprenticeship during their pre-service training and through teaching in the in-service training. This was evident from the following statement:

I have not gained adequate subject content during pre-service training in the regular classroom. However, when I went for the internship, where I had an opportunity to experience the actual and hands-on skills in a workshop, my knowledge was shaped tremendously. (Iyambo)

The above TVET teacher response underscores the importance of teaching knowledge and experience as a source of CK.

- **Collaborative learning communities**

The study findings indicate that TVET teachers drew CK from fellow TVET teachers and other industry experts. According to the TVET teachers, these communities come in the form of workshops, seminars, and even training organised by themselves. These communities allow TVET teachers to collaborate in sharing ideas, knowledge, and best practices for integrating technology into teaching. The findings reveal that TVET teachers went out of their way to be creative and develop strategies to exchange knowledge, ideas, and best practices for technology integration into teaching. The findings concur with Rahman et al. (2020) that collaboration among teachers is a crucial form of professional learning. It is valuable to see teachers working with their colleagues to boost their development efforts. The findings suggest that informal interactions allow teachers to exchange knowledge, experiences, and strategies.

6.3.2.2 Pedagogical Knowledge

- **Pre-service training**

The present study found that pre-service training did not contribute to the PK of TVET teachers as they had to undertake further training to become teachers after their trade training in TVET. For example, Iyaloo stated that her postgraduate diploma in TVET was a reasonable basis for her to acquire PK and develop TPACK the way she has done because her TVET training in metal fabrication did not equip her with PK. Iyaloo stated, *“I acquired my PK through the diploma in TVET at NUST”*. TVET teachers who only completed their trade diplomas to become industry experts were not equipped with PK during their pre-service training.

- **Self-initiated learning**

The analysis of the findings shows that self-initiated learning emerged as a significant source of PK among TVET teachers. The findings underscore the importance of TVET teachers' commitment to continuous learning. These teachers planned their self-initiated learning by setting goals, allocating resources, and assessing their progress through trial and error to

effectively impart knowledge to their students. This finding aligns with the principles of the SDL theory that individuals proactively identify their learning needs, set learning goals, determine learning resources, select and apply suitable learning strategies, and evaluate learning outcomes, either independently or with assistance from others (Knowles, 1975).

- **Teaching knowledge and experience**

The study found that some VET teachers obtained their PK from teaching knowledge and experience observed during their high school years. The findings align with Sæleaset and Friedrichsen (2021), who state that student experiences in school provided a foundation for pre-service teachers' understanding of instructional strategies, enabling them to connect their knowledge of how teachers teach, and students learn with effective teaching methods.

- **Collaborative learning communities**

An analysis of the findings reveals that collaborative learning communities also influenced the TVET teachers' PK because they were only prepared for the industry as experts in their training area. The pre-service training did not prepare them to become teachers and they seemed to lack PK. Collaborative learning communities allowed TVET teachers to learn pedagogical practices from other fellow TVET teachers to teach effectively. This finding aligns with Diack (2019), who refers to collaborative learning communities as PLCs and states that PLCs allow educators to engage in pedagogical brainstorming, exchange knowledge and experiences, and collaboratively address teaching challenges.

6.3.2.3 Technological Knowledge

- **Technology-related training**

The study found that the TVET teachers went through the VET ICT training in 2017, during which they acquired the TK knowledge, skills, and experiences necessary to integrate technology into their teaching practices effectively. The study also notes that this training helped TVET teachers become more proficient in using educational tools, software, and platforms, making their workflow more efficient. Subsequently, these professional development programmes also served as refreshers for TVET teachers to revise their knowledge during pre-service training and gain the latest knowledge in the field. The study argues that knowledge from professional development has empowered TVET teachers to self-initiate learning to integrate technology and potentially develop TPACK. This finding aligns

with previous studies that continuous professional development allows TVET teachers to stay updated on evolving student performance standards, adopt new instructional methods in various subjects, effectively use emerging educational technologies, and adjust teaching approaches to accommodate changing school environments and diverse student populations (Aldosemani, 2019; Grimus, 2020; Haleem et al., 2022;). However, the findings contradict Sam's (2021) study that evaluated pre-service visual arts teachers' TPACK skills. The study findings indicate that the TPACK competencies of pre-service visual arts teachers showed that their technology knowledge was less compared to their CK, which was substantial. The study attributes this scenario to the fact that most TVET teachers never went through teacher education training to become teachers.

Aldosemani's (2019) study uses a case study of a professional training programme planned and implemented to meet the national reform and improvement goals and enhance teachers' performance and practices. The study findings reveal that teachers strongly agreed on the effectiveness of workshop materials and training portfolios in equipping them with sufficient knowledge on using the discussed Web 2.0 tools. Furthermore, the finding supports Niess's (2016) research project, which focused on understanding and describing how instructors design online education to guide their TPACK professional development. The results indicate that the TPACK framework was valuable in recognising and addressing professional development needs by integrating technology with pedagogy and content, rather than treating it as an isolated component, which is essential.

TVET teachers also acknowledged that most of the technology-related training offered opportunities to develop specific TK and skills but sometimes did not comprehensively consider the relationships between technology, pedagogy, and content. The study argues that TVET teachers with only technological skills may face difficulties integrating technology into teaching. Other studies, such as Thaichon et al. (2023) and Srivani et al. (2023), indicate that technology-related training empowers users with the knowledge and skills required to effectively navigate and use technological tools, software, or systems. The study notes that having technological skills does not mean one can integrate technology into teaching.

The current study also highlights that since there is ongoing technological advancement, TVET teachers who receive technology-related training are better prepared to adapt to changes in the use of some technologies in an educational context. Therefore, technology-related training seems to prepare TVET teachers to stay abreast of the latest tools and trends, ensuring their

teaching methods remain relevant and engaging. This finding aligns with those of Prastyaningtyas et al.'s (2023) study that examined the influence of information technology on the progression of human resource careers. The study findings show that TVET teachers acquired an intensified level of adaptability, an essential competency in the swiftly evolving realm of technology, enabling TVET teachers to feel more at ease when acquiring proficiency in novel tools and technologies.

Furthermore, students interacted with the teachers more than before when technology was used to demonstrate specific topics. The study argues that when TVET teachers do not integrate technology into their lessons, they focus on using the traditional method of teaching, which is more teacher-centred than the student-centred approach. The study suggests that students become more passive and bored when the approach leans towards the teacher-centred approach; hence, interactions are encouraged when TVET teachers use technology. The findings support a study conducted by Serrano et al. (2019) on increasing awareness of higher education educators on how instructors can transform traditional face-to-face learning into blended courses to develop student engagement with both in-class and online approaches. The study found that TVET teachers who attended the VET ICT training could create interactive and dynamic learning experiences, fostering increased student engagement.

- **Self-initiated learning**

TVET teachers drew their CK and PK from other sources while self-learning to integrate technology. They also highlighted self-initiated learning as one of the sources from which they drew TK. The study's findings highlight the teachers' commitment to continuous learning and a proactive stance on technology integration. It was noted in this study that most TVET teachers intentionally dedicated time to exploring new educational technologies and experimenting in the classroom to enhance their familiarity. This finding corresponds to Chukwunemerem's (2023) study on the benefits of self-initiated learning activities as tools for improving university teachers' critical thinking. The study states that self-initiated learning enabled VET teachers to cultivate the skills necessary for continuous lifelong learning. The results indicate that educators engaged in self-reflection as learners and observed the changes in the learning process. Through trial and error, the teachers innovatively incorporated technology into teaching, ensuring it aligns with the curriculum and addresses the specific needs of their students. Therefore, TVET teachers were resilient and persevered throughout constructing knowledge and putting such knowledge into action by integrating it into teaching. TVET

teachers allowed students to explore, discover, and acquire various technological tools via self-initiated learning.

- **Teaching knowledge and experiences**

The study findings reveal that TVET teachers had gathered substantive experience to reflect on when integrating technology into teaching. Therefore, classroom experience, an in-depth understanding of the VET disciplines, and the reshaping of their pedagogical practices through trial and error equipped them with practical insights into integrating technology. Hence, prior knowledge and teaching experiences were other sources from which TVET teachers acquired TK. The study acknowledges that TVET teachers' engagement with various technological tools contributed to their TK. On the same note, Patphol et al.'s (2023) study on developing a learning management model that enhances creative self-initiated learning skills among school students in Thailand and prepares policy proposals and practical approaches for implementation in educational institutions noted that prior experience is a critical source of self-initiated learning because it shapes how individuals' approach, navigate and succeed in their self-learning. For instance, Iyambo had been teaching in VET for 26 years, during which he had accumulated substantial TK-related experience that he could draw upon for self-initiated learning. This ongoing cycle of self-initiated learning and development is instrumental in enhancing the overall competence of educators in TPACK.

TVET teachers admitted that previous experience in teaching allowed them to teach students in ways that worked for them when they were learners and could relate to their teachers at the time. The study argues that TVET teachers who bring previous experience to their practice to integrate technology effectively, aligning it seamlessly with their CK and pedagogical skills, become better at their work. Gerry et al. (2019) posit that combining prior experience with how TVET teachers use technology to present content allows for a more nuanced and adept application of technology in educational settings, ultimately enhancing the overall quality of teaching and learning experiences.

TVET teachers admitted that their prior experiences had changed their perceptions and fear of integrating technology into teaching and offered them opportunities to find ways to strengthen their TK. TVET teachers also acknowledged that since they underwent the TVET ICT training and self-initiated learned some of the practices, they hoped their TK would be shaped and honed throughout their career, making teaching with technology even better and more effective.

- **Collaborative learning communities**

The study findings disclose that some TVET teachers acquired TK from their fellow TVET colleagues in the field. TVET teachers acknowledged that they were part of collaborative learning communities through organised workshops and training for specific needs, sometimes by themselves and one-on-one support. The finding supports prior studies in that participation in communities of practice and collaborative learning with fellow educators fosters the exchange of ideas and best practices (Kowalczyk-Walędziak & Underwood, 2023; Trabona et al., 2019). The study emphasises that sharing experiences and strategies for using technologies in teaching and learning in VET within a supportive community of practice can be a valuable source of professional growth and development of knowledge related to TPACK.

So, TVET teachers acknowledged that collaborative learning communities allowed them to broaden and deepen their CK and PK and overall TPACK understanding. TVET teachers believed they primarily established collaborative learning communities during the FGD because they could learn from fellow TVET teachers when narrating their experiences, which they viewed as helpful for technology integration. They explained that hearing what others had done and continue to do to integrate technology into their classrooms provided them with new knowledge and insights.

Collaborative learning communities offered the opportunity to learn and share knowledge with others, the same knowledge that TVET teachers could pass on to those not part of this study. Similarly, Nihuka and Ngonile (2021) emphasised that teachers gain various insights through a community of practice, including integrating technology into teaching, developing pedagogy and instructional strategies, and designing curricula. Moreover, for effective teacher learning, collaborative learning communities should be characterised by school-based training that focuses on innovation; helping teachers apply new PK and CK in natural classroom settings; blended learning training which combines school-based learning with workshops or seminars; offering ongoing support from experienced educators or experts; and communication and collaboration in which members interact and collaborate using both technology and traditional methods.

The study suggests collaborative learning communities should foster an environment where collective learning can be nurtured, leading to a richer understanding of technology integration and TPACK development. However, besides knowledge sharing, TVET teachers also developed various skills, including critical thinking, communication, and teamwork.

- **Internet sources**

The findings show that TVET teachers self-learned by accessing information and participating in various online platforms, such as attending webinars and online courses related to the use of technologies. Previous studies have indicated that self-initiated learning allows flexibility and personalised exploration of specific areas of interest (Lalitha & Sreeja, 2020; Lemmetty & Collin, 2020). The study claims that internet sources are one of the sources of information and knowledge that are easily accessible to educators like VET teachers. The study suggests that the internet allows TVET teachers to search for information on either technology, pedagogy, or subject matter, depending on the need. The study argues that TVET teachers' access to the internet in terms of an available array of information gives them a better opportunity to integrate technology into teaching.

The TVET teachers acknowledged that content from the internet dramatically supported them because they could access it from anywhere, at any time, and from any device, such as their mobile phones, tablets, or laptops in the comfort of their homes and not necessarily when they were at work. In addition, access to internet sources allowed flexibility in terms of when, how, and where, and probably even why they were accessing them. The study suggests that internet content enables TVET teachers to access global discipline-specific information, which they can contextualise, model, and apply to enhance their teaching.

- **TVET teacher-student collaborative efforts**

Although not mentioned by the participants as a source, I picked up during the class observations that participants collaboratively integrated technology with students and were then able to draw their TK from students. The TVET teacher-student collaborative efforts refer to a partnership in which teachers and students work together to enhance learning outcomes in vocational and technical education settings. In this context, teachers are assisted and guided by students in using technology in their classrooms. The collaboration focuses on integrating TK into teaching for effective teaching. The study argues that students are competent in TK and operating digital technologies (Pendy, 2023), improving their technological skills, which puts them in a better position to assist teachers in the classroom. The study highlights that most TVET teachers did not build knowledge and understanding of the reciprocal relationship between technology, content, and pedagogies alone but, in some cases, with their students' help. This unforeseen interaction, where students actively support teachers' practices of integrating technologies, disrupts the conventional methods through which teachers

traditionally acquire TPACK. So, the current research revealed that TVET teachers recognised students as valuable contributors to the development of TPACK. The acknowledgement arose from certain students possessing advanced TK. Subsequently, teachers gained insights from students' feedback, facilitating reflective processes and improvement in their use of technology for teaching. According to Almusawi et al. (2021), today's students are more technologically advanced than their teachers, which has positioned them better to navigate their way through technological devices. Therefore, this study argues that students' TK and skills mean they can support and assist TVET teachers in integrating technology into teaching.

6.3.2.4 Technological Pedagogical Knowledge

Regarding TPK, the TVET teachers mentioned acquiring this knowledge from collaborative learning communities (CLCs). They noted that these opportunities inform and inspire them to explore integrating technologies into their classrooms. According to the teachers, the CLCs provide opportunities to reflect on how technology can improve lesson delivery. In addition, it was interesting to learn that TVET teachers understood the importance of making individual decisions on how technology supports pedagogy. Each TVET teacher recognised the need to determine the usefulness of technology and the best ways to integrate it into their lessons based on their specific contexts.

It was noted that being part of these CLCs was transformative for the TVET teachers, as it enriched their existing PK by incorporating technology (TPK). The TVET teachers acknowledged that these communities served as an initial step, offering insights and motivation to explore technology integration into their classrooms. From the TVET teachers' viewpoint, the CLCs prompted them to consider how technology could improve their lesson delivery and stimulated their interest in integrating technology.

6.3.2.5 Technological Pedagogical Content Knowledge

The study findings reveal that TVET teachers primarily developed their TPACK through a combination of pre-service training, teaching experience, and self-initiated learning. However, the significance of these sources varied across different TPACK components. For example, the teachers identified CLCs as the key source for PCK, which focuses on teaching approaches specific to TVET. In contrast, pre-service training was highlighted as the primary source for CK.

For PK, most teachers credited self-initiated learning and CLCs as the main contributors, with teaching experience playing a secondary role. Focus group discussions further emphasised how teaching experience enriched TPACK development. These experiences were classified into self-initiated learning practices, collaborative efforts with students, and engagement in CLCs.

Self-initiated learning became a key and powerful resource, providing teachers with the skills needed to effectively incorporate technology into their teaching practices. The study shows that self-initiated learning emerged as the source of all knowledge (TPACK) for TVET teachers. TVET teachers opted for self-initiated learning to acquire knowledge that they could not otherwise acquire from other sources such as pre-service, teaching and learning experience, TVET teachers–student collaborative efforts, CLCs and the internet.

6.3.3 Drivers and constraints for integration and use of technology in teaching

The findings indicate that TVET teachers undertook several activities in their attempts to integrate technology into their lessons. The extent of TVET teachers' self-initiated learning reinforced these activities, which differed from one VET teacher to another. The study notes that activities such as accessing subject content through online platforms such as YouTube, searching educational websites and using WhatsApp groups on their android to communicate with fellow TVET teachers and students alike allowed VET teachers to integrate technology. The study noted that TVET teachers knew the activities to undertake and how to self-initiate learning to integrate technology. The findings support previous research that self-initiated learning activities that aid in technology integration include online courses and webinars, social media engagement, and peer collaboration and feedback (Curran et al., 2019; Toro-Troconis et al., 2019).

In addition, it is worth noting that TVET teachers undertook self-initiated learning for a few reasons. One of the reasons was that some TVET teachers did not undergo the TVET ICT training on technology integration and did not possess TK from their pre-service training. The second reason was that the technology-related training workshop the TVET teachers attended lacked a specific context for the subject, and the content provided or taught was not tailor-made for VET. Therefore, TVET teachers were faced with negotiating working or integrating technology in two distinct environments, one from which training was provided and the one in which they were to teach and integrate technology.

Furthermore, TVET teachers acknowledged that self-initiated learning benefited them by planning and designing it according to what they needed to learn, setting their own goals and timelines, and assessing their learning. The finding confirms Knowles' (1975, p. 18) definition of SDL as "a process in which individuals take the initiative, with or without the help of others, in identifying learning needs, setting their goals, identifying learning materials, developing learning strategies and seeing that they achieve the learning outcomes". The findings further confirm that self-initiated learning is an adult learning approach involving andragogy; hence, they controlled the process and did it at their own pace (Asonglefac, 2021; Soydan, 2018).

However, throughout the self-initiated learning process, TVET teachers were faced with constraints that distracted them from trying to learn to integrate technology into teaching. The study highlights that the selected TVET teachers encountered significant challenges due to the limited time required to integrate technological tools into their instruction. For example, Angula pointed out the time-constraint nature of setting up technologies during class sessions. Often, by the time the equipment was ready for use, most of the 60-minute class period had already elapsed. As a result, students struggled to grasp the abstract concepts being taught and felt frustrated due to the rushed nature of the technology's application. The findings suggest that the subsequent agitation among students could impede their learning experience, leading to dissatisfaction with using these technologies. This finding aligns with previous studies, such as Zunica's (2023) study on investigating the adverse effects of time pressures in inhibiting a teacher's desire to use technology. Their analysis identified three time-related obstacles: insufficient time for lesson preparation and syllabuses overloaded with content. Similarly, Calleja and Camilleri (2021) indicated that teachers experienced setbacks and a sense of unpreparedness when compelled to transition lesson studies exclusively to online platforms. In addition, Francom et al. (2021) and Oghly (2023) highlight that teachers face challenges in finding the time to develop teaching approaches that use technology, including lesson preparation. The finding also concurs with the TPACK framework, which explicitly acknowledges that some teachers may not embrace new technologies for various reasons, including a shortage of time to incorporate technology in their lessons (Koehler & Mishra, 2016).

Furthermore, the findings reveal that the lack of policies to guide and direct technology integration, internet connectivity, information overload, and limited technological devices constrain TVET teachers' self-initiated learning. The findings concur with Kapolo's (2023) study on exploring the effectiveness of eLearning platforms in TVET within Namibia. The

results show that self-initiated learning The results indicate that self-initiated learning influenced student teachers' emotional regulation and workload.

6.3.4 Harmonising the support that initiates self-TPACK development

The study shows that the TVET teachers needed support in various ways to integrate technology into teaching. Thus, the study found that TVET teachers' desire for professional development programmes would help them acquire and improve their TPACK for technology integration into the VET context.

Most TVET teachers highlighted that attending workshops, seminars, and any knowledge-sharing platforms related to technology integration and transfer programmes would contribute immeasurably towards effective teaching. However, several professional development methods for teachers provide a uniform strategy for incorporating technology, even though teachers work within varied contexts of teaching and learning (Smith et al., 2020), for which TVET teachers request more specific designed training. The findings show that TVET teachers require regular workshops and training tailor-made for the TVET context to serve as a refresher and enable them to improve their TPACK. The finding aligns with Leger et al.'s (2023) study on exploring the conditions that influence practice to develop knowledge before, during, and upon completion of a professional development programme. The findings indicated that professional development is an evolving process of professional openness, reflection, and development that generates the best results if continued over time in communities of practice and when focused on job-embedded responsibilities.

Furthermore, TVET teachers revealed that one of the supports they would need is to be allowed opportunities to learn from countries recognised for their advanced knowledge, skills, and practices in specific fields or industries on VET matters, share knowledge, and be able to initiate change in their systems such as Germany, Switzerland, and Finland. The TVET teachers specified transfer programmes to other regional VET centres or beyond. The study suggests that NTA, as the custodian of most VET centres in the country, can facilitate transfer programmes for their TVET teachers with partner institutions in other countries. The finding resonates well with Mamatova et al.'s (2022) study on the effectiveness of information digital technologies in public relations management specialists' training on the blended learning model for public administration bodies. The results show that transfer/exchange programmes have become a tradition in many higher education institutions. They create a platform for teachers to be exposed to different teaching methods, research approaches, and work practices that

enhance knowledge and skills. In addition, the TVET teachers indicated the need for modern technological tools to access and integrate technology into teaching effectively.

6.4 Proposing a New TPACK Framework for the VET Teachers

The present study has unveiled a new perspective on the development of TPACK for TVET teachers in VET. This perspective is founded on two fundamental premises: TPACK development in VET as a context and among TVET teachers. From these premises, the current study asserts that the development of TPACK for teachers in VET contexts should not be conflated with that of other educators in higher education. For TVET, the three primary components comprising TPACK (technology, pedagogy, content) are typically considered distinct entities. This division in the prevailing operational TPACK framework proposed by Mishra and Koehler (2006) aligns with research on TVET teachers, where such distinctions are conceptually sound (see Figure 3.2). However, this study in VET teaching highlights a distinctive dynamic where pedagogy and content are deeply interconnected and often overlap. Technology emerges as a critical element, enhancing and transforming the established PCK into TPACK. Rather than being merely an "add-on," technology acts as an integrative force, enabling more effective teaching and learning practices within the VET context.

Consequently, the study proposes a distinct perspective on TPACK development tailored to teachers in the context of VET in Namibia as a developing country (see Figure 6.1). This would signify an evolution of technology integration and TPACK development in VET. This perspective recognises that the traditional TPACK framework, primarily rooted in other educators' training, does not fully address the complexities and dynamics of teaching in Namibia's VET centres.

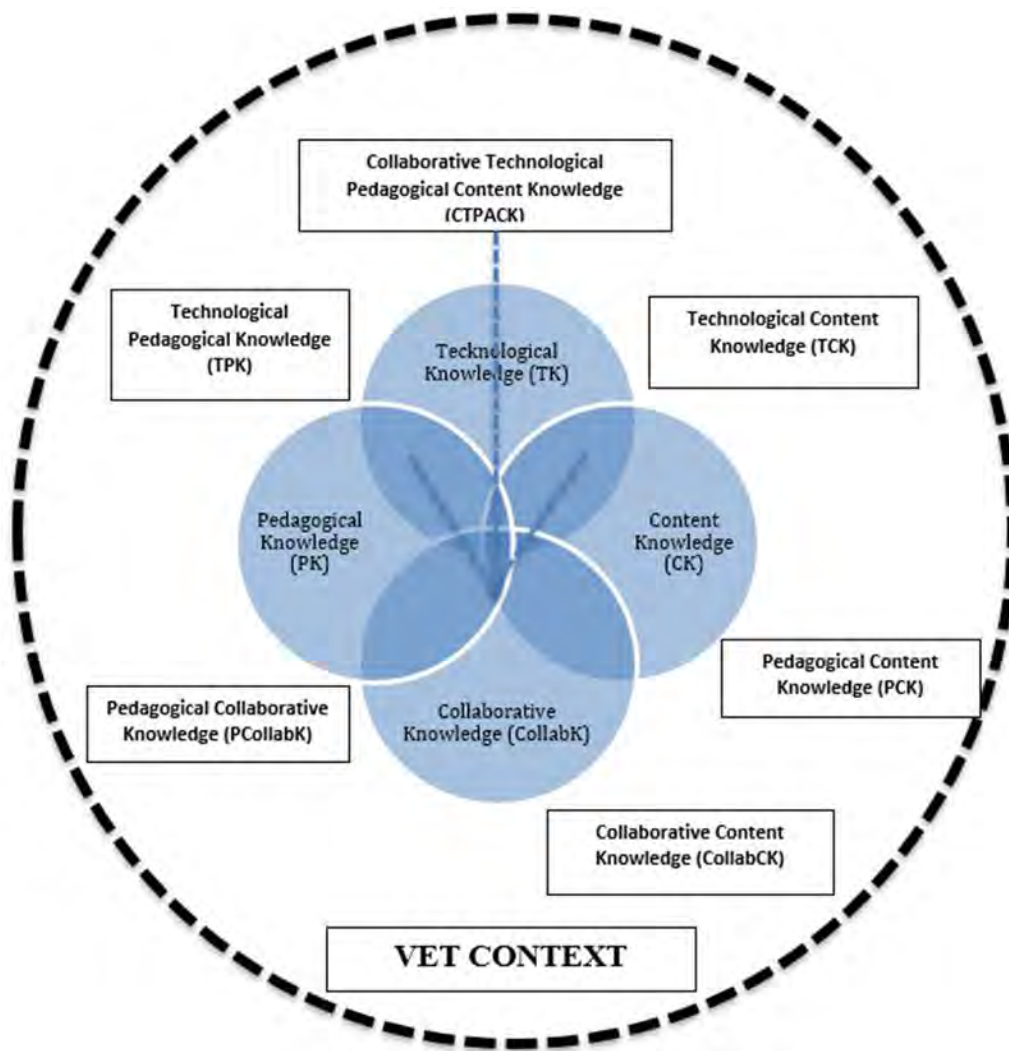


Figure 6.1: Proposed TPACK Framework for VET teachers (drawn by the researcher)

A noteworthy finding of the present study highlights the significant role of the TVET context in shaping TPACK development within Namibia's VET institutions. This finding supports the existing literature that highlights the centrality of context in developing TPACK, prompting the need to revise the prevailing operational TPACK model initially presented in the study (see Figure 3.1). The adjustment was made to accentuate the significance of context (see Figure 6.1), which had not been explicitly illuminated in the earlier prevailing operational TPACK detailed in Chapter 3, albeit implied across the study. This adjustment is not merely cosmetic; it symbolises a paradigm shift as it explicitly includes “collaborative efforts” – here referred to as “collaborative knowledge” – denoted by CollabK (as depicted in Figure 6.1). This reshaped framework underscores the notion that comprehending the specific VET context within which technology is applied is indispensable for TVET teachers to integrate technology into TVET

settings effectively. The following subsections delve deeper into the two fundamental premises of the TPACK model for TVET teachers: TPACK development in TVET contexts and among TVET teachers.

The proposed TPACK framework speaks to the results of several authors, such as and Elmaadaway and Abouelenein (2023), and Pareto and Willermark (2019), who suggested that researchers can expand the TPACK framework to accommodate diverse viewpoints and changes in educational paradigms within alternative educational settings.

6.4.1 TPACK development in the VET context

The emphasis on the VET context within the proposed framework signifies a crucial departure from the conventional TPACK model, highlighting the profound collaboration on TPACK development and teaching in Namibia as a developing country. This recognition stems from understanding the challenges and opportunities that necessitate collaborations. In VET institutions, limited access to resources, including technological infrastructure and up-to-date educational materials, is not new and has presented a unique set of hurdles for teachers. These challenges necessitate collaborations to bridge the knowledge gap in technology integration and deliver high-quality education. Moreover, students depicting different learning needs and styles are also noteworthy, as TVET teachers must be attuned to their students' learning needs and styles; integrating technology can help ensure that the content and teaching methods are tailored to meet these diverse requirements effectively.

Recognising the importance of context, the framework proposed in this study acknowledges that effective TPACK development for TVET teachers in these environments demands a nuanced understanding of context dynamics. It underscores the idea that TPACK cannot be a one-size-fits-all approach; instead, it must be shaped by the distinctive challenges and opportunities presented by the TVET context in Namibia as a developing country. This supports TPACK development's contextuality, as suggested by Mishra and Koehler (2006). I engaged with the participants who indicated that they make collaborative efforts to individually initiate learning with others, from others, and on their own, on how to integrate technology into teaching. Moreover, the present study demonstrates how collaboration shapes the TPACK development process, reaffirming the centrality of the TVET environment in teaching. By explicitly incorporating 'collaboration' and other elements, the proposed framework acknowledges that teachers must develop a deep awareness of the collaborative environment within which they operate. This collaboration aspect becomes a foundational component in

their ability to integrate technology effectively, design relevant pedagogical strategies, and tailor content to meet the unique needs of the students in VET institutions. Therefore, the importance of context in this proposed framework becomes a crucial testament to the intricate interplay between teaching and the contextual environment in which it unfolds, highlighting the need for a context-specific approach to TPACK development in VET institutions in Namibia.

6.4.2 TPACK development among TVET teachers

To delve deeper into the distinctions between this proposed framework and the traditional TPACK model, the present study's findings demonstrate an equally pronounced overlap between teachers' TK, PK, and CK, in a collaborative manner within the TVET context (refer to Figure 6.1), suggesting that the way TVET teachers develop TPACK differs significantly from educators in other higher education institutions. This difference is largely due to the extensive practical classroom experience and hands-on exposure that TVET teachers gain throughout their teaching careers. This teaching experience has likely allowed them to refine their pedagogical techniques, aligning them closely with the intricacies of the content they teach with the help of collaborative efforts from students, partners, and collaborations among the TVET teachers in the teaching and learning process, including self-reflection on self-initiated learning, and learning from YouTube videos and other internet sources. The teaching experience also emphasised the importance of adapting TPACK to meet the diverse needs of learners in collaborative efforts in the TVET context, resulting in a deeper integration and overlap of TPCK (refer to Figure 6.1).

Specifically, the study argues that teachers in VET centres have had the opportunity to adjust their pedagogical methods based on their diverse students' learning needs and styles over time. This adaptability has led to a more natural blending of PK and CK reinforced by collaborative efforts for technology integration, as they have honed their abilities to convey content in ways that resonate with their students.

Consequently, some TVET teachers primarily require collaborative efforts within the TVET context to develop TPACK, as they already possess a robust foundation of CK. Thus, in this study, TVET teachers could develop an understanding of TPACK through the proposed TPACK model specifically designed for VET.

The study suggests that TPACK development in the TVET context is influenced by collaborations that allow TVET teachers to understand students' abilities, interests, and prior knowledge related to technology. Furthermore, TVET teachers know the diverse students' learning needs and styles, so their pedagogy aligns with the content to meet such needs. Therefore, context, as an addition to TPACK, reveals an understanding of the environment within which collaborative learning principles are reinforced and the ability to engage in effective teamwork and cooperation.

The interconnectedness of these four knowledge domains (TK, PK, CK, and Context) forms the contextual-TPACK (C-TPACK) framework, highlighting the essential role of context in effective technology integration. This framework recognises that technology integration is a social activity in which TVET teachers, students, and expert countries should collaborate.

6.4.3 Implications of the proposed C-TPACK model in VET centres

The implications of the proposed framework could be far-reaching and offer valuable insights for teachers and researchers in VET institutions in Namibia, a developing country, and other similar regions. Firstly, by recognising collaborative efforts, self-initiated learning experiences such as YouTube and internet sources, and the importance of tailoring TPACK in VET teaching approaches to accommodate it, the framework equips TVET teachers with a more effective and collaborative-sensitive toolkit. This can empower the TVET teachers to deliver high-quality teaching that resonates with their students' unique needs and learning styles. The proposed framework for TVET teachers' TPACK development may be instrumental in improving learning outcomes in VET settings, where students may come from diverse cultural backgrounds and have varying levels of prior knowledge. In a broader global context, the proposed framework can offer researchers the lens to view TPACK development in other TVET environments. The proposed framework, derived from the TVET teachers' perspectives, experiences, and voices, is crucial to understanding TPACK development in TVET. These voices have been notably absent in most TPACK research, making this study's insights particularly significant.

Contextual-TPACK (C-TPACK) in VET has several implications that can positively impact the learning environment, teaching methods, and overall educational outcomes, as outlined below.

First, C-TPACK emphasises that contextual environments are influenced by collaborative efforts among educators, bringing together their technological, pedagogical, and content knowledge. This contextual environment fosters a sharing of expertise, ideas, and resources among vocational educators, leading to a more enriched teaching and learning environment.

Second, implementing C-TPACK necessitates collaboration among VET teachers in the integration of the technologies as ongoing professional development for vocational teachers. This continuous learning ensures that teachers stay current with technological tools and pedagogical strategies, ultimately improving the quality of vocational education.

Third, C-TPACK may encourage the contextualisation of design for vocational education technology integration activities that closely align with real-world applications. This approach supports teachers in integrating specific technologies in the classroom that may also prepare students for the practical challenges they may encounter in their future careers, bridging the gap between classroom learning and workplace demands.

Fourth, contextual concerns in C-TPACK can facilitate the development of inclusive teaching practices that cater to diverse learners in vocational education. TVET teachers can better address all students' unique needs and learning styles by incorporating various technological tools and instructional methods.

Fifth, leveraging contextual matters such as industry alignment and labour markets, technology advancements, limited funding and resource allocation, and TVET teachers' training among others to technology integration, C-TPACK can enhance teachers' technology integration experiences, making teaching more interactive.

Overall, C-TPACK in vocational education can spearhead TVET teachers' technology integration, leading to a balanced relationship between technology, pedagogy, content, and contexts. The following section summarises the chapter.

6.5 Summary of the Chapter

The study highlights several critical observations about TVET teachers' efforts to integrate technology into teaching within the VET context. The study emphasises the need for comprehensive support and professional development tailored to the unique needs of TVET teachers in the VET sector. The findings reveal that the centrality of context in technology integration is paramount in TVET, as teachers highlighted the importance of targeted training

tailored to address the diverse teaching and learning environments within VET. The findings further stress the value of learning from global best practices through transfer and exchange programmes with countries renowned for their VET expertise. Such programmes are seen as vital opportunities for contextual knowledge exchange, exposure to diverse pedagogical approaches, and fostering meaningful improvements in Namibia's TVET educational systems.

Moreover, the study emphasises that access to relevant technological tools is essential for effective technology integration, empowering TVET teachers to respond to the evolving needs of students within specific VET contexts. This chapter, therefore, underscores the significance of context-sensitive training and collaboration to enhance TVET teachers' TPACK. These efforts collectively support the successful and contextually relevant integration of technology into VET teaching practices.

The chapter settled by proposing a new TPACK framework for individual VET teachers. The framework aims to enhance teaching tailored to specific contexts and offer valuable guidance for developing TPACK among TVET teachers in VET centres. The forthcoming and concluding chapter summarise significant discoveries, new insights gained, recommendations, and concluding remarks.

CHAPTER SEVEN

SUMMARY OF FINDINGS, RECOMMENDATIONS, AND CONCLUSION

7.1 Introduction

The previous chapter discussed the study's findings in alignment with the research objectives, literature, and theoretical frameworks. This chapter summarises the findings, provides recommendations, and concludes the critical insights from the comprehensive exploration of TVET teachers' experiences integrating technology into teaching within the VET context. The study examined the perspectives, insights, and experiences of individual TVET teachers' TPACK development in Namibia's VET centres. By analysing the individual TVET teachers' self-reported perspectives, insights and experiences, the study uncovers valuable insights that contribute to understanding TPACK development and its implications for TVET teachers and the principles of the SDL theory. The study synthesises the study's findings, offering a condensed overview of significant observations, TVET teachers' perspectives, insights, experiences, and implications for future practices. Additionally, it provides practical recommendations to address the identified challenges and enhance technology integration in VET teaching. Finally, the chapter concludes by summarising the overarching implications of the study and suggesting potential avenues for further research in this crucial domain of education.

7.2 Summary of the Findings

This section summarises the findings based on the specific research objectives. The findings are organised into four main sections: individual understanding and evolution of TPACK, self-initiated learning activities contributing to TPACK development, drivers and challenges in integrating technology into teaching and learning, and harmonising support systems to foster self-driven TPACK development.

7.2.1 The individual understanding and shifting of TPACK understanding

The study highlights the novelty of TPACK in the VET context, contributing to the limited knowledge and insight. The study reveals a general lack of clarity and confusion among TVET teachers regarding the description of TPACK. This ambiguity arises from the dual perspectives

of TPACK as a new concept, a form of knowledge, and a framework. Not all TVET teachers could articulate TPACK. However, some TVET teachers, despite struggling with the description of TPACK, have successfully integrated technology into teaching, emphasising the interactions between technology, pedagogy, and content.

The study suggests that the TVET teachers' understanding of TPACK, and its relationship enables them to use various technological tools effectively. Some TVET teachers have integrated technology without becoming aware of the knowledge related to TPACK being developed. TVET teachers have used technology in their classrooms since taking up their teaching jobs, which has been influenced by personal use and the technical nature of VET trades. Various technological tools, including smartphones, laptops, and traditional classroom equipment, are used based on accessibility and individual needs. TVET teachers also use technology for assessment design and monitoring student performance, with YouTube playing a significant role in resource gathering and teaching facilitation.

The study also showed that the TVET teachers display reduced TPACK competency. When analysing the specific components of TPACK, the TVET teachers reported stronger proficiency in non-technology domains (CK, PK, PCK) compared to technology-related domains (TK, TPK, TPACK). Notably, among the technology-related domains, TK stood out as the area of greatest expertise. This observation supports the theory that, although having TK is essential, the effectiveness of technology integration depends on the harmonious combination of TK, pedagogical approaches, and content mastery to improve teaching and learning experiences. This finding suggests that to advance technology integration beyond superficial use and foster more learner-centred pedagogical approaches, TVET teachers must be equipped with technological expertise and a deep understanding of all TPACK domains.

7.2.2 Individual self-initiated learning activities and TPACK development

The study examined the sources of knowledge domains associated with TPACK that TVET teachers draw upon during self-initiated learning on technology integration. Notably, self-initiated learning emerged as a pivotal and influential source, equipping teachers with the necessary skills to effectively integrate technology into their teaching. The TVET teachers' proactive engagement in exploring and experimenting with technology independently allowed them to align these technological tools with the curriculum's objectives. This self-initiated learning process exemplifies the resourcefulness and autonomy demonstrated by the teachers, who actively seek ways to enhance their teaching practices through technology. This

observation underscores the narratives of the SDL theory that teachers independently self-learn as individuals accountable for their own future and tend to be more motivated and self-directed.

Moreover, an intriguing and unexpected finding emerged regarding the role of students in shaping teachers' TPACK development, referred to as the TVET teacher-student collaborative effort. The study highlighted that TVET teachers benefit from collaborating with students who have advanced TK. This dynamic demonstrates a two-way learning process in the digital age, where teachers and students engage in reciprocal learning experiences. These insights challenge traditional paradigms of teaching dynamics and highlight the evolving teacher-student relationship in a technology-rich educational environment. The findings revealed a multifaceted TPACK development process among individual TVET teachers, where students' technological expertise not only enhances teachers' TK but also supports the integration of technology into teaching by introducing tools and approaches that students understand better than their teachers. This collaborative effort allows TVET teachers to work together with students to improve their TK and integrate technology into teaching.

In addition to individual efforts for self-initiated learning, the study underscores the role of CLCs, YouTube videos, and internet sources which enhance peer interactions and enrich TK. Through meaningful exchanges with fellow TVET teachers, TVET teachers have the opportunity to share innovative strategies, best practices, and valuable insights related to technology integration. This collaborative approach fosters a culture of continuous improvement and accelerates CK, PK, and TK's growth by tapping into collective wisdom. Therefore, collaborative learning has become a source of TVET teachers' TPACK, allowing them to share technological integration insights and learn from one another.

A significant source of TPACK development is technology-related training, which emerged as an effective means of equipping teachers with the necessary skills to integrate technology into their teaching. Some TVET teachers participated in the 2017 TVET ICT training to acquire knowledge, skills, and experiences for effective technology integration. Despite the TVET ICT training being general and not context-specific, TVET teachers acknowledged the positive impact that the training had on teaching using technology. Through the ICT training, TVET teachers could draw TK and create interactions with pedagogy and content for technology integration. Therefore, professional development is a nurturing ground for CK, PK, and TK. The study suggests combining these sources of TVET teachers' TPACK which will contribute to a more comprehensive and nuanced understanding of TPACK among TVET teachers.

7.2.3 Drivers and constraints for integration of technology into teaching and learning

The study identified various activities that drive and constrain TVET teachers' efforts to integrate technology into teaching. The study revealed that TVET teachers are driven by the availability of online platforms to access subject content. Therefore, TVET teachers access various content that they can impart to their students through online sources. TVET teachers can transmit such content to learners through technological tools to help them better understand concepts.

Moreover, access to technological tools allows TVET teachers to communicate with fellow TVET teachers and students. Through meaningful exchanges with colleagues and students, TVET teachers have the opportunity to share innovative strategies and valuable insights related to technology integration.

The study also sheds light on the TVET ICT training provided to TVET teachers to equip them with TK to incorporate technology into teaching. Interestingly, TVET teachers reported that technology-related training lacks a specific context for the subject, and the content provided or taught is not tailor-made for VET. This observation inhibits them from acquiring the knowledge necessary for technology integration into teaching. The finding implies that TVET teachers must have TK and skills across all domains for effective technology integration.

On the same note, the study revealed that TVET teachers who were not trained through the TVET ICT training self-initiated learning about navigational technological tools to integrate technology into teaching. However, TVET teachers face internet connectivity problems, inhibiting their self-initiated learning to incorporate technology into teaching. Similarly, some TVET teachers mentioned workload as a constraint as they have to cover extensive content within limited time frames, delaying their self-initiated learning progress for technology integration. The study also discovered that TVET teachers lack policies to guide and direct technology integration.

7.2.4 Harmonising the support that initiates self-TPACK development

The study emphasises the need for comprehensive support for TVET teachers to successfully integrate technology into teaching in the VET context. TVET teachers strongly desire professional development programmes, including workshops, seminars, and knowledge-sharing platforms for technology integration. These programmes allow TVET teachers to acquire the necessary knowledge and skills for effective teaching and technology integration.

It is also on these same platforms where TVET teachers can learn to create connections between technology, pedagogy, and content.

However, TVET teachers supported more specific and tailored training programmes to address their unique needs in TVET. This would allow them to obtain knowledge and skills specific to their fields, making incorporating technology into their classrooms simple. The study underscores the importance of ongoing professional development in communities of practice, emphasising that continuous and focused professional development programmes generate optimal results and enhance technology integration and TPACK development over time.

Furthermore, TVET teachers indicated the need to be provided opportunities to learn best practices on technology integration from the best of the best in the region and beyond. The TVET teachers divulged that these opportunities would allow for information and knowledge sharing in the technology field and all knowledge domains. The exchange programmes are believed to provide opportunities for TVET teachers to learn, share knowledge and best practices, and bring about positive changes in the TVET systems. The study supports the idea that transfer/exchange programmes would allow TVET teachers to benefit from exposure to diverse pedagogical and work practices, enhancing their knowledge and skills.

In addition, TVET teachers revealed the need for more financial resources to acquire modern technological infrastructure for VET institutions. Access to these technological tools is crucial for effective technology integration and allows TVET teachers to accommodate students' diverse learning needs.

Table 7.1: Research questions and major findings

Research Questions	Major Findings
How do TVET teachers self-report and describe their TPACK in VET?	The study reveals a lack of clarity and understanding of TPACK among TVET teachers. While some TVET teachers effectively integrate technology into teaching, not all can articulate TPACK. Understanding TPACK enables TVET teachers to use various technological tools effectively, but the study shows that some TVET teachers integrate technology without being aware of the TPACK concept. The novelty of TPACK in VET contributes to limited knowledge among TVET teachers. Therefore, TVET teachers use of technology is influenced by personal and vocational training experiences. Consistent professional development programmes are crucial to addressing TPACK discrepancies among TVET teachers.
What TPACK sources do TVET teachers draw upon during self-initiated learning of technology integration into the classroom?	• TVET teachers acquire their TPACK from various sources while self-initiated learning to integrate technology into teaching: • Pre-service Training: TVET teachers with academic or vocational qualifications acquire foundational CK and PK through pre-service training, crucial to technology integration readiness. • Technology-related training: TVET teachers use ICT training to gain skills and knowledge for effective technology integration. • Teaching experience: TVET teachers reflect on their teaching experience as students and teachers in VET to identify knowledge gaps and set learning goals while leveraging prior experience for self-initiated learning. • CLCs: The study also indicates that some TVET teachers collaborate with colleagues to exchange ideas and best practices, fostering professional growth within supportive communities. • Internet sources: TVET teachers use online platforms such as YouTube videos and instructional channels to access TPACK-related resources, enabling flexible and personalised self-initiated learning. • TVET teachers–student collaboration: Classroom observations suggest that TVET teachers collaborate with students to integrate technology into teaching. Students are

	technologically advanced and have better knowledge of technology than the teachers, positioning them well to assist teachers in navigating various LMS during their classes and developing TPACK. The study indicates that combining these sources contributes to a comprehensive understanding of TPACK among TVET teachers.
How do self-initiated learning activities support and constrain TVET teachers to integrate technology into teaching?	Self-initiated learning activities supporting technology integration include accessing online platforms such as YouTube videos, using WhatsApp groups for communication, and watching and listening to instructional videos. Similarly, engaging colleagues to share ideas and best practices enables TVET teachers to integrate technology in teaching and develop TPACK. However, internet connectivity, lack of policies to guide and direct technology integration, and limited TK hinder TVET teachers' self-initiated learning. In addition, TVET teachers report being overwhelmed by the information overload, covering extensive content within restricted time frames.
What support do TVET teachers need to integrate technology into teaching and develop TPACK?	The study underscores the necessity of comprehensive support for TVET teachers to effectively integrate technology into VET teaching. TVET teachers strongly desire tailored professional development programmes, including workshops and seminars specifically focused on technology integration, recognising the limitations of generic professional development strategies. Ongoing professional development within communities of practice is deemed crucial for optimal results over time. In addition, TVET teachers advocate transfer/exchange programmes with countries renowned for VET expertise, to facilitate knowledge sharing and exposure to diverse pedagogical practices.

7.3 Development of New Knowledge in TVET

Furthering the discussion on the findings, this section brings to light the new insights revealed by this study. This study's distinctive contribution arises from its shift away from the standard approaches seen in prior studies. Instead, the current study delved more profoundly into the intricate process of TPACK development through the filters of TVET teachers' self-reported perspectives, insights and experiences, collaborative efforts influences, and experiential

nuances that shape the development of TPACK. The present study contributes to the theory and methodology of TPACK development, as demonstrated below:

7.3.1 Theoretical contributions

Firstly, this investigation into the development of TPACK within TVET in Namibia introduces a range of contributions that broaden both the existing boundaries of knowledge and address gaps highlighted in Section 2.8. The primary contribution of this current study is its provision of fresh insights into TPACK development in Namibia's VET context. As demonstrated in Chapter 2, the majority of TPACK research has been conducted within Western and developed countries regions of the world (Dewi et al., 2021 [Turkey]); Major & McDonald, 2021 [USA]; O'Brien, 2015 [Australia]; Polikarpus et al., 2023 [Estonia]; and Sánchez-Prieto et al., 2020 [Spain]; Voogt & McKenney, 2017 [Netherlands] among others, resulting in a less explored TPACK landscape within the southern regions of the world.

To my knowledge, this study marks an uncharted territory within Namibia's VET institutions. While existing TPACK research in the Namibian context has focused primarily on primary and secondary education and higher education, VET have been neglected. This present study emphasises VET, establishing a novel research niche within TVET education in Namibia. This shift of focus from primary and secondary education and teacher education to VET, specifically concerning the advancement of TPACK in TVET teachers within VET, has not been previously explored in the Namibian context. This research addresses a notable knowledge gap by studying TPACK development in TVET teachers within VET institutions. This cohort has been inadequately examined in preceding studies.

The TPACK framework suggests that effective teaching with technology requires more than just proficiency in using technology. Integrating TK with pedagogical and content expertise necessitates creating meaningful learning experiences. In other words, TVET teachers need to understand how to select and use appropriate technologies to support and enhance their pedagogical goals and the content they are teaching. The study revealed that TVET teachers seem to integrate technology in education and know how to create connections between technology, pedagogy, and content. The study attributes TVET teachers' knowledge of connecting technology, pedagogy, and content to their teaching experience, self-initiated learning, and learning from fellow TVET teachers.

Furthermore, TPACK recognises that these three knowledge domains are not independent but interconnected and influence one another. Effective technology integration occurs when teachers balance and integrate all three types of knowledge into their teaching practice. The intersection of the three circles representing TK, PK, and CK within the more prominent teaching and learning context depicts the balance (see Section 3.2.1).

Secondly, the present study's review of TPACK studies spanning the period from 2010 to 2022, as presented in Section 2.8, uncovered a notable absence of research explicitly delving into the context of rural schools. Notably, only three recent investigations conducted in Indonesia (Imansaria et al., 2020), Estonia (Polikarpus et al., 2023), and Turkey (Summak et al., 2011) were conducted in a TVET setting. This evident gap underscores the insufficient global exploration of the TVET context throughout the evolutionary trajectory of research on TVET teachers' TPACK. As a result, the current study contributes significantly to the TPACK literature by focusing explicitly on its development within the TVET setting in Namibia as a developing country. This endeavour enhances the understanding of TPACK development across diverse educational settings and provides insights to guide effective pedagogical methods and policies tailored to VET institutions.

Thirdly, as elucidated in Section 2.8, the realm of TPACK knowledge has predominantly been shaped by research in TVET in some African countries and beyond (Alagaraja et al., 2014; Ayonmike et al., 2015; Autor, 2014; Baumgarten et al., 2016; Guo et al., 2020; Hashim et al., 2022; Pongo et al., 2015;) and technology integration into VET and other contexts globally (Saud et al., 2011; Summak et al., 2011). Consequently, the current understanding of TPACK largely stems from viewpoints expressed by TVET teachers in other contexts, such as developed nations, with comparatively limited insights regarding TVET teachers in Namibia as a developing nation (Nepembe & Simuja, 2023). Thus, the present study contributes theoretically by pushing the boundaries of TPACK understanding, casting light on the evolution of context within a relatively unexplored domain – that of TVET teachers. To offer more precision, this research deeply explores the perspectives, insights, and experiences that shape the development of TPACK among TVET teachers in Namibia.

Fourthly, this study's proposed C-TPACK model offers a series of theoretical contributions to TPACK development for TVET teachers in Namibia VET institutions. The model was shaped by the teaching and self-initiated learning practices that TVET teachers experienced while integrating technology into their classrooms. These practices were developed collaboratively

through interactions between TVET teachers, students, and partners, including fellow educators (see Section 6.4). Moreover, the study's proposed C-TPACK model explicitly encompasses 'contextuality,' denoted as "C". This represents a new contribution to the conventional model, firmly emphasising the critical importance of context in TPACK development. Therefore, the proposed C-TPACK framework for individual TVET teachers advocates a highly tailored approach to TPACK, recognising that a one-size-fits-all strategy does not suffice.

In addition, the proposed model emphasises a critical differentiation between TVET teachers and educators in other higher education institutions, showcasing how hands-on classroom experience enables them to integrate the components of TPACK naturally and seamlessly within the unique context of the TVET learning environment. Beyond theoretical considerations, the practical implications of the proposed model are substantial. The theoretical considerations encapsulate the essence of TPACK and its evolution in VET, amplifying VET teachers' perspectives, insights, and experiences – a traditionally overlooked demographic in TPACK research. This amplification contributes to an in-depth comprehension of TPACK development, particularly in VET, and it holds the potential to benefit similar contexts on a global scale. As the first study in Namibia to combine TPACK and SDL, it offers a unique theoretical contribution distinct from previous research using different frameworks. In addition, this research sets a foundation for future studies in similar contexts, enabling them to explore TPACK development through the combined theoretical perspectives introduced here.

7.3.2 Methodological contributions

The current study adopted a qualitative, multiple-cases approach to explore TVET teachers' technology integration into teaching and TPACK development in VET. The qualitative approach allowed this study to collect an in-depth individual perspective and holistic view of the TVET teachers about technology integration in TVET. The multiple cases offered a unique scenario in which individual cases' experiences, practices, and challenges were studied, resulting in a unified perspective. The study provided a deeper understanding of technology integration and TPACK development through qualitative and multiple cases. At the same time, TVET teachers' *voices* were heard when they brought their individual yet unique cases to the fore.

However, most TPACK literature reviewed in this study focused on quantitative research (Al Gamad et al., 2016; Ayonmike et al., 2015; Blackwell et al., 2014; Bwalya & Rutegwa, 2023;

Kanbul et al., 2022; Koh et al., 2010; Nurhadi et al., 2018; Ramadan et al., 2018; Summak et al., 2011; Tarman et al., 2019) and a few on mixed methodology (Hartley, 2014; Jiménez Sierra et al., 2023; O'Brien, 2015;). These studies also focused on single cases.

Moreover, the literature shows that most studies using the SDL as a theoretical framework only looked at self-initiated learning regarding learners and students, not teachers or educators. This scenario not only gives the impression that only learners or students could adopt self-initiated learning but paints a contrary picture to the narratives of andragogy in adult education, regardless of whether one is a learner, student, or teacher. The current study explored self-initiated learning from the TVET teachers' perspective, signifying a new trend towards knowledge acquisition for technology integration and TPACK development.

Equally, the study found an absence of literature that combines the TPACK framework and SDL theory to explore technology integration into teaching and the subsequent development of TPACK. Instead, the reviewed literature addressed TPACK and the SDL theory as separate, standalone concepts, with no studies examining their intersection.

Some studies (Munyanyo, 2023; Schad et al., 2021; Shambare, Simuja & Olayinka, 2022;) that have been reviewed have combined TPACK with socio-cultural theory by Vygotsky, TAM, and others. Therefore, this study is the first to explore technology integration, combining the unique perspectives of TPACK and SDL. TPACK emphasises that TVET teachers must possess TPACK to integrate technology into teaching effectively. However, TPACK does not indicate how TVET teachers should acquire such knowledge. Therefore, the SDL theory focuses on what and how TVET teachers can gain TPACK, either by providing new knowledge or improving and updating existing knowledge they once acquired through their pre-service training or professional development programmes.

Furthermore, this study used questionnaires, semi-structured interviews, non-participatory classroom observation, and focus group discussions for data collection. However, most reviewed quantitative studies (Al Gamad et al., 2016; Ayonmike et al., 2015; Blackwell et al., 2014; Bwalya & Rutegwa, 2023; Jiménez Sierra et al., 2023; Kanbul et al., 2022; Koh et al., 2010; Nurhadi et al., 2018; Ramadan et al., 2018; Summak et al., 2011; Tarman et al., 2019;), and a few using mixed methodology (Hartley, 2014; O'Brien, 2015;) adopted questionnaires/surveys to collect data. Even a few studies that adopted qualitative methods (Halim & Hashim, 2019; Knolton, 2014; Polikarpus et al., 2023; Saud et al., 2011;) used

survey/questionnaire, (Simon, 2015) used observation and semi-structured interviews, and Voogt and McKenney (2017) only used focus group discussion.

The study claims that its combination of the two theoretical frameworks (TPACK & SDL) is new in research regarding understanding integrating technology into teaching. Furthermore, when the study combined SDL with TPACK, I created the analytical lens to analyse the collected data that would inform TVET teachers to design personalised learning experiences that leverage technology to meet individual students' diverse needs and interests. Nonetheless, the combination of the TPACK and SDL frameworks within this study signifies a fresh and innovative approach, extending the theoretical underpinnings of TPACK research within the developing nation's context, particularly in Namibia. The existing body of literature concerning TPACK development in Namibia lacks theory triangulation, particularly the combination of TPACK and SDL frameworks.

Moreover, previous studies frequently focus solely on the TPACK framework, which limits the depth of the insights gained. This aligns with Koehler and Mishra's (2006) assertion that, in the complex and evolving field of technology integration in education, relying on a single framework fails to address the multifaceted problems that arise. This study offers a more detailed and nuanced examination of TPACK development in VET institutions by combining the influential frameworks of TPACK and SDL. By integrating these two frameworks, the research provides a comprehensive understanding of the intricate relationship between TVET teacher knowledge, contextual factors, and technology integration, specifically in the context of Namibian VET institutions.

The study further moved into a reflective workshop, which was not meant for data collection but was considered groundbreaking for consistent reporting to ensure the reliability and trustworthiness of data. Further, the reflective workshop enabled me to engage participants to gather feedback on the research process, including recruitment methods, data collection techniques, and communication strategies. This feedback was valuable for improving the quality and relevance of the research, ensuring that it was more responsive to the needs and concerns of the participants. Moreover, the reflective workshops facilitated empathy and understanding between the participants and me. So, by reflecting on each other's experiences, challenges, and perspectives, the participants and I developed a greater appreciation for each other's roles and contributions to the research process, fostering stronger relationships built on trust, respect, and mutual understanding.

The innovative methodology employed in this research holds massive implications for the TVET community. It emphasises the importance of diversifying the toolkit of research practices to embrace inclusivity. In a globalised yet distinctly local educational environment, approaches like focus group discussions enable a thorough exploration of TPACK that is rigorous and aligned with cultural and contextual sensitivities. The ensuing section presents practical implications and recommendations for further research.

7.4 Implications for Practice and Further Research

This section offers practical applications and suggests recommendations for future research, building on the analysis of present research results and the introduction of innovative perspectives. The study's recommendations provide practical and implementable advice derived from its findings while also proposing potential directions for further advancing research in the future.

7.4.1 Implications for practice

Since this is the first study on technology integration into teaching and TPACK development in VET in Namibia, its lines of inquiry have revealed uncharted ways for more research. Therefore, the potential of this interdisciplinary approach lies in its capacity to improve scholarly conversations by identifying patterns, similarities, and differences. Ultimately, this contributes to a deeper understanding of the evolution of TVET teachers' TPACK. The study revealed that TVET teachers are integrating technology into their classrooms, which has led to TPACK development. Further, the study noted that TVET teachers have incorporated technology despite their limited understanding of TPACK. Also, for leveraging, TVET teachers undertook self-initiated learning to equip themselves with the know-how and acquire the TPACK by contextualising their environments and being able to integrate technology into teaching. Despite TVET teachers' ability to integrate technology into teaching, they experienced many challenges throughout the self-initiated learning processes for technology integration. Therefore, these results possess several practical implications for the TVET teachers, heads of centres, and policymakers.

7.4.1.1 *TVET teachers*

The findings of this study have significant scientific and practical significance implications for TVET teachers. From a scientific perspective, the investigation of TVET teachers' technology

integration contributes to a deeper understanding of their self-initiated learning to acquire the TPACK and develop TPACK within the TVET context. The current study also demonstrated that SDL is domain-specific in the context of TPACK development. Consequently, the significant findings from this research not only inform scholars about the SDL principles undertaken but also provide a deeper understanding of how TVET teachers use various strategies to tackle authentic instructional challenges.

The TPACK framework provides a structured approach to understanding the diverse knowledge areas required to integrate technology effectively into teaching. By combining TPACK with the SDL theory, the study offers TVET teachers a pathway to identify their knowledge gaps related to technology use and encourages them to take the initiative in self-initiated learning to address these gaps. This dual approach enables TVET teachers to enhance their understanding of technology integration while fostering their professional growth. Moreover, it empowers them to develop a balanced and interconnected understanding of technology, pedagogy, and content, ultimately improving their teaching practices and better meeting the needs of their students. With the above information, TVET teachers can benefit by acknowledging areas of improvement and then seeking customised professional assistance to address these knowledge gaps:

- a) Encourage TVET teachers to self-initiate learning and be able to work with technology to evoke critical thinking and learning.
- b) Create communities of practices to share best pedagogical practices and knowledge with other TVET teachers.
- c) Teachers are to be provided with specific technologies for their discipline, empowering and motivating them to understand the importance and benefits of integrating technology into their classrooms.

7.4.1.2 *Heads of centres*

As the demand for technology integration in education grows, so does the need to provide technological infrastructure including internet connectivity and technical support in VET centres and capacity building for heads of centres. Some VET centres are publicly led, while others are privately led. Hence, for those owned and led by the central government, the onus is on the government to provide them with the necessary technological infrastructure and support services. Owners of privately owned and led VET centres should ensure they are adequately equipped with modern technological infrastructure. Equipping these centres should also

involve offering comprehensive training for the professional development of heads of centres. Consequently, heads of centres can also provide support to their TVET teachers based on the support and assistance they receive from the government.

7.4.1.3 *Policymakers*

The implications for policymakers underscore the importance of proactive measures to support the evolution of TVET teachers' TPACK in vocational training institutions. Considering the above, policymakers play a pivotal role in creating an enabling environment that fosters continuous improvement and innovation in vocational education. The following policy concerns emerged as concerns across all cases:

a) Curriculum development for technology integration

A critical policy concern is the need to develop curriculum guidelines that explicitly emphasise the integration of technology into vocational training. Such curriculum development would ensure that TVET teachers are equipped with the necessary TPACK to address the evolving needs of students and align teaching practices with modern industry requirements.

b) Resource allocation for technology infrastructure

Adequate resource allocation to improve technology infrastructure in vocational training centres is essential for enabling TVET teachers to integrate technology effectively into their teaching practices. Without sufficient technological resources, efforts to enhance teaching and learning through technology integration remain limited.

c) Funding for improving teaching practices

Policies should prioritise funding for further research to assess the impact of TPACK integration in VET. Regular evaluations can inform policy adjustments, ensuring that strategies remain aligned with the evolving nature of technology in vocational education and the needs of the workforce.

d) Alignment TVET teacher teaching practices with industry standards

It is critical to align TPACK development in VET with industry standards. This alignment ensures that TVET teachers equip students with the technological skills and knowledge demanded by the current job market, enhancing the relevance and employability of graduates.

7.4.1.4 *TVET teachers training institutions*

The current study has indicated that most TVET teachers were fully armed with CK but had limited technological and pedagogical expertise, which they enhanced through self-initiated learning. This finding suggests that TVET institutions must develop training programmes tailored for VET, equipping TVET teachers with technological and PCK in preparation for teaching and learning and not merely for industry practices. Notably, the technology module embedded in the education course only fosters technological skills and not technology integration into teaching. Therefore, training institutions should:

- a) Embed a TPCK module in their TVET teachers' training programme curriculum and across multiple educational subjects.
- b) Develop collaborative projects needing TVET teachers in training to craft lesson plans or instructional materials that seamlessly integrate technology, content, and pedagogy to encourage understanding of how technology contributes to effective teaching and learning.
- c) Provide TVET teachers with Centre Based Studies to expose them to classroom experiences as part of their training. This experience would also provide TVET teachers with knowledge, awareness, and practice in the range of roles for TVET teachers, including integrating technology into teaching.
- d) Move away from the one-size-fits-all and tailor-make technology integration training for the unique and specific VET disciplines.
- e) Develop follow-up professional development programmes beyond formal training, such as workshops and seminars to establish cutting-edge technologies and progressive pedagogical practices, and
- f) Establish coaching and mentoring programmes for novice TVET teachers by well-experienced TVET teachers who have been in the field for quite some time to foster adapting to teaching in technology-rich and infused classrooms.

7.4.1.5 *Global applicability of the study's recommendations*

Although the principal emphasis of this study's contribution pertains to VET in Namibia, the recommended suggestions may or can be applied to other regions with similar characteristics, considering the global relevance of TPACK.

Essentially, these suggestions highlight two essential factors pivotal for successful technology integration. These factors include the proficiency of TVET teachers and the contextual elements influencing their capacity to integrate technology effectively. As a result, the practical advice or recommendations outlined earlier can provide valuable direction for TVET teachers and educational policymakers in diverse settings. Thus, the recommendations presented in this study not only enhance the current knowledge base regarding TVET teachers' TPACK and technology integration but also contribute to the ongoing conversation about the role of technology in education.

7.4.1.6 *Enhancing professional TVET teachers' development*

The study findings have highlighted specific gaps in TVET teachers' proficiency and understanding of TPACK for effective technology integration into teaching. Hence, it is crucial that professional development moves beyond just instructing on the use of technological tools to help TVET teachers seamlessly embed technology into their instructional strategies. Insights from the research can guide the design and implementation of targeted professional development programmes for vocational TVET teachers. Therefore, professional TVET teachers' development should be enhanced by:

- a) Tailoring the professional development programmes to the unique and specific VET disciplines only and not combining it with other educators' programmes such as pre-service and in-service primary or secondary education teachers.
- b) Providing these professional development programmes within or at VET centres environment or a familiar space similar to that of the TVET teachers for the immediate application of the newly acquired knowledge and skills, and
- c) Provide training on technology integration to technology integration coordinators or officers to be well-capable to assist and support TVET teachers when integrating technology into their classrooms.

7.4.1.7 *Infrastructure and resource allocation*

TVET centres are still faced with persistent and unresolved challenges. Although the VET centres studied are in major towns throughout the country. The current study has discovered three significant factors that negatively influence technology integration into teaching. These are unstable internet connectivity, limited technological infrastructure, and limited technology proficiency among TVET teachers. The problem of unstable internet connectivity is a national concern due to the increased demand for connectivity. The study recommends that institutions purchase additional internet technologies and bandwidth to boost connectivity.

Moreover, the study has found that most centres face inadequate technological infrastructure provision. At the same time, some are shared between TVET teachers, restricting their use by all TVET teachers simultaneously.

7.5 Recommendations

This study recommends the following:

The study's findings indicate that most training provided to TVET teachers is general and lacks relevance to the specific context of vocational education. As a result, there is a need for targeted, context-specific training programs that focus on the effective integration of technology within TVET disciplines.

The study findings also indicate several challenges faced by the teachers such as slow internet connectivity, lack of institutional ICT policies and lack of support for self-initiated learning which impacted technology integration. TVET institutions should foster a culture of technology integration by providing better internet connectivity, support for self-initiated learning, and developing technology policies.

Moreover, TVET institutions should create a platform to establish formalised structures for collaboration among TVET teachers, both within and across institutions.

7.6 Recommendations for future research

This study has brought to the fore contemplations for future research. Therefore, future research could contribute significantly to understanding how TVET teachers' TPACK evolves in VET institutions and how this evolution impacts pedagogical practices and student outcomes in the dynamic landscape of vocational education.

The study adopted a qualitative and multiple-case study of six TVET teachers who indicated willingness to further participate in the study in the questionnaire; they were interviewed using semi-structured interviews, observed through non-participatory observation and involved in focus group discussions. Therefore, conclusions drawn from the data collected only provided personal experiences, views, and practices, which were more specifically related to those TVET teachers and could not represent the entire VET population. Consequently, studies should be undertaken focusing on a more prominent representative to obtain views and understanding from broader perspectives and gather qualitative data that can offer a comprehensive understanding of the complex interplay between TVET teachers' TPACK, instructional practices, and VET outcomes. On the same note, since the study was exploratory, I would recommend a formative interventionist study to empower TVET teachers on the integration of technology using TPACK as a framework.

This study started the evolution of technology integration and TPACK development in Namibia's VET. However, the study focused on the present time. Therefore, to effectively study the evolution of technology integration and TPACK development in VET, the study recommends that future longitudinal studies that track the evolution of TVET teachers' TPACK can be conducted over an extended period. This approach could provide a more nuanced understanding of the factors influencing TPACK development and how it aligns with the changing landscape of vocational education.

7.7 Limitations of the Study

As with any human endeavour, the present study and its findings are not without limitations. These include factors related to methodology, the data collected, and the particular contexts of the participants involved. It is essential for researchers to openly acknowledge these limitations and discuss their potential impact on the study's outcomes (Theofanidis & Fountouki, 2018; Tracy, 2019;). This transparency enhances the credibility of the research and guides future scholars in building upon the existing knowledge base (Tracy, 2019). This study faced the following limitations.

Firstly, the study included 25 participants who were selected using criteria sampling to complete the questionnaire. The participants were selected based on specific criteria such as teaching levels 1-3 and leaving TVET teachers either owning a technological device or using technology to teach, which may have been influenced by contextual factors. From this group, six participants indicated willingness to take part in the semi-structured interviews, non-

participatory lesson observations, and focus group discussions, sharing their perspectives, insights, and experiences on technology integration and TPACK development in VET. While the sample size for these additional methods was small, it provided valuable in-depth insights. However, this practice may have limited the possibility and extent of applying them to other VET institutions that were not part of the study across the country and in similar contexts elsewhere. This broader approach could have provided deeper insights into contextual variations in TPACK development. The study suggests that selecting institutions as cases could have included a larger number of teachers, allowing for a more thorough exploration of TPACK development across various contexts, such as private versus public institutions and rural versus urban settings. The broadening would enable a more comprehensive understanding of how TVET teachers integrate technology and develop TPACK and their experiences across different VET contexts.

The FGDs were conducted via WhatsApp calls due to the challenge of bringing all participants together face-to-face. This may have affected the engagement and the quality of interactions between the participants and me and among the participants. Since the discussions were audio recorded during the WhatsApp calls, the participants were accorded an opportunity to listen to the recordings and clarify their points during the reflective workshop. In addition, I integrated the WhatsApp focus group discussions with other qualitative methods, like semi-structured interviews and classroom observation to enhance validation and enrich the findings.

Furthermore, the study could have been susceptible to biases and subjectivity due to its reliance on the participating TVET teachers' self-reported perspectives and personal experiences. Their individual viewpoints, convictions, or prior experiences might have influenced their responses, thereby introducing potential biases into the collected data. This propensity for bias was further pronounced by the study investigating the TPACK development of teachers who report to the researcher in their line of work, potentially influencing how they responded. To counter balance this, the study adeptly employed a range of data sources to mitigate these potential biases and cross-referenced the ensuing findings. However, it is essential to note that the participants were purposively selected based on their voluntary participation and school location. Consequently, the researcher urges readers to exercise caution while interpreting the findings of this study.

7.8 Major Conclusion of the Study and Reflections

This section integrates all the elements discussed throughout this thesis. The research examined the multi-case of TVET teachers' technology integration and TPACK development in Namibia's VET institutions.

This study embedded two distinct theoretical frameworks, TPACK and SDL, which played a significant role in designing the research questions and served as an analytical lens for the study findings. The SDL provided a lens to understand how TVET teachers' self-initiated learning helped them acquire the TPACK for effective technology integration and TPACK development. At the same time, TPACK provided a lens to understand the types of expertise TVET teachers require for effective teaching and technology integration. Combining TPACK and SDL brought about rich descriptions of the phenomenon, strengthening the analysis and interpretation of the findings.

The study adopted a qualitative, multi-case approach embedded into the interpretive paradigm. This multi-case study on the Evolution of Instructors' TPACK in Vocational Training Centres has provided valuable insights into the dynamic nature of instructional practices within these specialised educational settings. Examining multiple cases has allowed for a nuanced understanding of how TVET teachers integrate TPACK over time.

The study comprised 25 participants selected via criterion sampling from VET institutions across the country based on teaching levels 1-3, owning a technology, using technology to teach, and indicating a willingness to partake in semi-structured interviews, non-participatory lesson observation, and focus group discussion. From this group, six cases when answering the questionnaire indicated willingness to further participate in semi-structured interviews, non-participatory observation and focus groups. The study collected data through a questionnaire, which served as a foreground, semi-structured interviews, non-participatory lesson observation, and focus group discussion. The study analysed the data thematically through Microsoft software with the support of the NVivo software version 22.

Moreover, the findings emphasise the significance of contextual factors in shaping the evolution of TPACK among vocational teachers. The interplay between institutional culture, resource availability, and instructional strategies has emerged as a crucial determinant in developing effective TPACK. Therefore, the TPACK development emphasises the need for

tailored professional development initiatives that consider the unique contextual challenges faced by teachers in vocational training institutions.

Furthermore, the study has illuminated the pivotal role of TVET teachers in fostering student success in vocational education. The correlation between TVET teachers' TPACK and student outcomes highlights the importance of ongoing professional development to enhance instructional practices and adapt to the evolving landscape of technology in vocational training.

As I reflect on the implications of this research, it becomes evident that future endeavours in this domain should consider longitudinal studies, mixed-methods approach, and inclusive research practices. Long-term investigations would provide a deeper understanding of the sustained impact of professional development initiatives on instructors' TPACK.

This multi-case study contributes to the broader discourse on TPACK in vocational training institutions, providing a foundation for future research. By addressing contextual nuances, emphasising the pivotal role of TVET teachers, and advocating targeted professional development, the study advances efforts to create educational environments that effectively prepare students for success in their vocational careers. As technology continues to evolve and vocational training remains integral to workforce development, enhancing TVET teachers' TPACK is essential for the sustained growth and relevance of vocational education.

7.9 Personal Reflections of the PhD Research

Completing this thesis has been a deeply transformative experience, both academically and personally. Throughout this journey, I encountered challenges that pushed me to develop perseverance, adaptability, and critical thinking. However, these obstacles also provided valuable learning opportunities that have greatly contributed to my intellectual and professional development.

One of the most fulfilling aspects of this research was the chance to explore the topic that relate to my person experiences of teaching in TVET . Engaging with existing literature, analysing data, and drawing conclusions allowed me to gain a more comprehensive understanding of the my experiences and others and its practical significance. Additionally, this study has enhanced my ability to critically evaluate information and synthesise complex concepts skills that will undoubtedly benefit me in future research.

The research process was not without difficulties. At times, I faced challenges in locating relevant resources, refining my methodology, and maintaining a structured writing approach. There were moments of self-doubt and frustration, particularly when results did not meet initial expectations. However, through perseverance and the support of my supervisor, peers, and mentors, I overcame these hurdles and gained greater confidence in my research capabilities.

Beyond academics, this experience has reinforced the importance of time management, discipline, and resilience. Balancing research with other responsibilities such as fulltime job and being a single mother to 4 children required careful organisation and prioritisation. This journey has strengthened my commitment to continuous learning and self-improvement, encouraging me to stay curious and open to acquiring new knowledge.

Looking forward, I see this thesis not as a conclusion but as a foundation for further academic and professional growth. The insights gained from this research will guide my future work, and I am eager to apply them in practical settings. I hope that my findings contribute meaningfully to TVET and inspire further exploration in this area.

Although this thesis presented numerous challenges, it has been an incredibly rewarding experience. The lessons learned have shaped me into a more resilient and knowledgeable individual, and I am grateful for this opportunity. I look forward to building upon these experiences as I continue my academic and professional journey.

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APPENDICES

APPENDIX A: LETTER TO NAMIBIA TRAINING AUTHORITY

Victoria Nepembe
P O Box 97507
Maerua Mall
Windhoek

Namibia Training Authority
P.O. Box 70407
Khomasdal
Windhoek
Namibia

Dear, Mr Haufiku

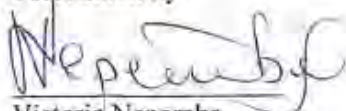
REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN THE VOCATIONAL EDUCATION & TRAINING (VET) CENTRES

I am Victoria Nepembe, presently studying for a PhD degree at Rhodes University. As part of my programme, I am required to conduct research on an aspect of interest to contribute to the knowledge and understanding of the issues under study. I hereby humbly request your permission to conduct research with instructors in the VET centres. The research is titled: *Evolution of Instructors' TPACK in Vocational Training centres: A multi-case study*. The purpose of the study is to examine Instructors technological pedagogical content knowledge in vocation education and training centres in Namibia.

The study will involve myself administering questionnaires to 25 purposively selected Instructors; conducting semi-structured interviews with 6 Instructors; conducting focus group discussions with 6 Instructors and conducting non-participatory observation with 6 Instructors' lessons, 3 times each. I wish to assure your good office that should permission be granted; I will strictly uphold all the ethical standards as required by the Namibia Training Authority.

This research has been approved by the Rhodes University Ethical Standards Committee, and the Rhodes University Education Department Higher Degrees Committee. 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.

Yours Sincerely


Victoria Nepembe

APPENDIX B: LETTER TO NAMIBIA COLLEGE OF OPEN LEARNING

Victoria Nepembe
P O Box 97507
Maerua Mall
Windhoek
21 July 2023

Namcol, YetuYama Centre
Private Bag 15008
Katutura
Windhoek
Namibia

Dear, Ms Nampira

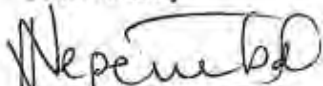
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I am Victoria Nepembe, presently studying for a PhD degree at Rhodes University. As part of my programme, I am required to conduct research on an aspect of interest to contribute to the knowledge and understanding of the issues under study. I hereby humbly request your permission to conduct research with instructors in the VET centres. The research is titled: *Evolution of Instructors' TPACK in Vocational Training centres: A multi-case study*. The purpose of the study is to examine Instructors technological pedagogical content knowledge in vocation education and training centres in Namibia.

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This research has been approved by the Rhodes University Ethical Standards Committee, and the Rhodes University Education Department Higher Degrees Committee. 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.

Yours Sincerely


Victoria Nepembe

APPENDIX C: LETTER TO WINDHOEK VOCATIONAL TRAINING CENTRE

Victoria Nepembe
P O Box 97507
Maerua Mall
Windhoek
21 July 2023

Windhoek Vocational Training Centre
Private Bag 13334
11 Rooivalk Street, Khomasdal
Windhoek
Namibia

Dear, Sir/Madam

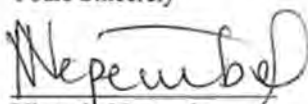
REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN THE VOCATIONAL EDUCATION & TRAINING (VET) CENTRES

I am Victoria Nepembe, presently studying for a PhD degree at Rhodes University. As part of my programme, I am required to conduct research on an aspect of interest to contribute to the knowledge and understanding of the issues under study. I hereby humbly request your permission to conduct research with instructors in the VET centres. The research is titled: *Evolution of Instructors' TPACK in Vocational Training centres: A multi-case study*. The purpose of the study is to examine Instructors technological pedagogical content knowledge in vocation education and training centres in Namibia.

The study will involve myself administering questionnaires to 25 purposively selected Instructors; conducting semi-structured interviews with 6 Instructors; conducting focus group discussions with 6 Instructors and conducting non-participatory observation with 6 Instructors' lessons, 3 times each. I wish to assure your good office that should permission be granted; I will strictly uphold all the ethical standards as required by the Namibia Training Authority.

This research has been approved by the Rhodes University Ethical Standards Committee, and the Rhodes University Education Department Higher Degrees Committee. 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.

Yours Sincerely


Victoria Nepembe

APPENDIX D: QUESTIONNAIRE TOOL

SECTION A: BIOGRAPHICAL AND BACKGROUND INFORMATION

(Please, answer by placing a tick (✓) in the relevant box for each statement below)

1. How do you describe your gender?

Female	
Male	
Others	

2. In which age brackets are you?

20 and below		41-50	
21-30		51-60	
31-40		61+	

3. I am,

Black		White	
Coloured		Others, (please, specify)	
Indian		None	

4. Which discipline(s) do you teach (indicate all that apply)?

Automotive Mechanics		Office Administration	
Plumbing and Pipe fitting		Bricklaying and plastering	
Carpentry		Metal Fabrication	
Fitting and Turning		Electrical General	
Others (please specify)			

5. Which VET level are you teaching?

Level 1	
Level 2	
Level 3	
Others,	

6. How long have you been teaching in VET?

0-4		16-20	
5-10		21-25	
11-15		26+	

7. What is the highest level of qualification attained?

Undergraduate Degree		Doctorate (PhD)	
Honour's Degree		Others	
Master			

8. What degree (s)/Certificates have you attained? Please select all that apply.

Bachelor of Science		Master of Education	
Bachelor of Education		Master of Science	
Postgraduate Diploma		Other	

9. I am available to take part in the following activities (Please select all that apply).

Interview	
Observation	
Focus group discussion	
I am not available in any of the above activities	

SECTION B: TECHNOLOGY USE

Please select a suitable answer by (✓) in the appropriate box:

1. Do you use technology in your lessons?	Yes		No	
	Never	Sometimes	Rarely	Every Day
2. How often do you use technology in your lessons?				
3. I use technologies for:				
• Search for information				
• Make teaching presentations				
• To have students work in a collaborative way				
• To prepare educational materials				
2. Do you use the following internet services?				
• Email				
• School Website				
• Learning Management System (e.g., Moodle; Blackboard; WebCT)				
• Other:				
3. Do you receive technical support from the System Administrator/ ICT Coordinator?				

SECTION C: INSTRUCTORS' UNDERSTANDING OF TPACK

(Please choose one answer only)

Which definition best describe your understanding of technological pedagogical content knowledge?	
TPACK is a framework to understand and describe the kinds of knowledge needed by an Instructor for effective pedagogical practice in a technological-enhanced learning environment	
TPACK considers what Instructors need to know to be able to integrate technology; focuses on three domains of teacher knowledge: technology, pedagogy, and content knowledge	
TPACK is a model to describe the knowledge requirements for Instructors to integrate technology in teaching	
TPACK is a framework to describe the kinds of knowledge needed by an Instructors to implement effective pedagogy in a technology-enhanced learning environment	
I have no idea what TPACK means	

SECTION D: TPACK & TECHNOLOGY INTEGRATION IN VET

	Agree	Disagree	Neutral	Strongly Agree	Strongly Disagree
1. I can use educational technologies to teach.					
2. I keep up with important advanced technologies.					
3. I can learn new technologies easily.					
4. I can play around with the technology.					
5. I know a lot about different technologies.					
6. I know which technologies are best suited for my teaching.					
7. I have the technical skills to use a variety of technologies.					
8. I have knowledge about technologies that I can use to better understand subject content.					
9. I can use technology that promote pedagogical approaches in my lessons.					
10. I am familiar with the subject content as prescribed by the VET curriculum.					
11. I know how to use technology to assess learners' performance in the classroom.					
12. I have sufficient subject knowledge for all my VET trades.					

13. I can select technologies to use that strengthen my subject content, pedagogies and students understanding.					
14. I know how to change my teaching styles to suit both theoretical and practical lessons.					
15. I am familiar with the teaching and learning materials prescribed for the VET discipline and level of trade.					
16. I know what strategies to use to stimulate students' critical thinking in the subject matter.					
17. I know how to use specific technologies to teach specific VET trade concepts/topics.					
18. I can choose technologies that makes it easy for students to understand VET concepts.					
19. I can share my technological pedagogical content knowledge with other instructors.					
20. I can choose topics that combine the content with technology and teaching methods.					

APPENDIX E: SEMI-STRUCTURED INTERVIEW TOOL

My name is Victoria Nepembe. Thank you for agreeing to meet with me today. The purpose of our meeting is to discuss technological infusion that is affecting the teaching and learning process in the education system. This is because you need to possess technological pedagogical content knowledge to integrate technology in teaching. The information collected will be kept confidential and for research purpose only and that participants' details such as names will not be revealed in the notes and the research report. Additionally, you are free to withdraw from the FGD. Since the interview will be recorded, I request that you give consent by signing the consent form for participation and audio recording below:

INFORMED CONSENT FORM FOR SEMI-STRUCTURED INTERVIEW

I will be asking you some questions for which there is no right or wrong answer. Only your views and opinions about technological pedagogical content knowledge is needed. I will be taking notes of our discussion as well as audio record at the same time. However, if you do not feel comfortable to be recorded, the audio cannot be used, and for parts to be excluded from audio recording, it can be switched off. You are also assured that your identity will be kept confidential and will at no time be revealed when transcribing the notes and audio recording. You are further assured that I am only allowed to keep the notes and audio recordings for up to 6 months after completion of my thesis, upon which all recordings should be wiped.

Please tick the following boxes to indicate that you have read and understood the information to participate in the research interviews:

- ☐ I confirm that I have read and understand the subject information part of this form
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reasons and without adverse consequences
- ☐ I understand that all the information will be kept strictly confidential and no personal details such as names will be revealed
- ☐ I understand that the interviews will be note and audio recorded and that I am free to withdraw my consent to be audio recorded and/or for some parts thereof not be recorded
- ☐ I understand that all information notes and audio recorded will be deleted 6 months after completion of the thesis

Please tick one of the following boxes to indicate whether you agree to participate in the research interviews:

☐

ree to take part in the research interviews without audio recordings

☐

ree to take part in the research with audio recordings

☐

not agree to take part in the research interviews with or without audio recordings

SIGNATURE: _____ DATE: _____

SEMI-STRUCTURED INTERVIEW QUESTIONS

Instructors' experience teaching with technology

1.What were your first-hand experience teaching with technology?

- Explain how you have used technology in your classrooms.
- Explain how has technology assisted you design assessment tools (question papers, worksheets etc.,)?

2.How has technology impacted your teaching?

- How have workshops on technology changed or not the pedagogical practices you use to teach?

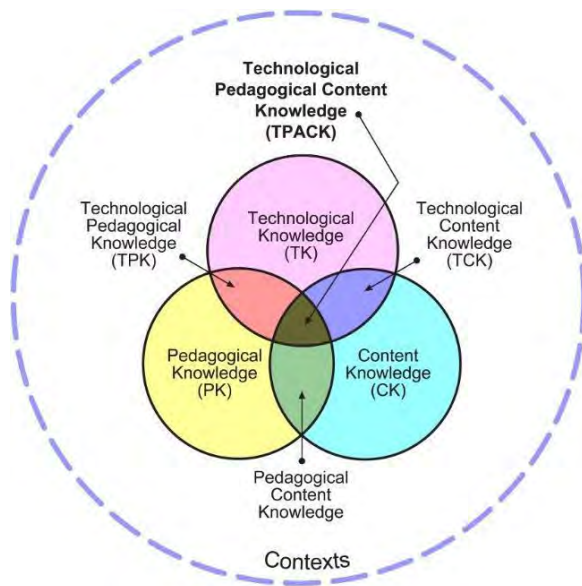
3.What are your views on teaching with technology?

- What challenges did you experience teaching with technology?
- How do you anticipate teaching with technology in the future?

4.How would you describe technology integration?

- Describe your experiences learning to use technology for teaching.

5.Please provide answers to the following questions based on the TPACK diagram below:



- With the help of the TPACK diagram above, where would you place your TPACK?
- What is your view of the “T” position in TPACK with relation to vocational training disciplines and why?
- How has teaching with technology in VET impacted your teaching and students’ understanding of their modules?

APPENDIX F: TPACK LESSON OBSERVATION SCHEDULE

PART 1: BACKGROUND INFORMATION

Name Of Observer	
Name of Instructor	
Name of VET Centre	
Name of Region	
VET Trade And Level	
No. Of Students In The Class	
Observation Date	
Observation Time	

1. Lesson objectives

What are the lesson objectives? (Did the Instructor state them? Are they in line with the topic being taught?)

2. Technological tools visible in the classroom

What different technological tools are in the classroom and how many?

PART 2: LESSON OBSERVATION GUIDE

This is the section in which the actual activities observed will be noted. The activities to be observed will be based on the following questions. The observation will be twofold: what I observe and what I think could have happened for each separate question.

Lesson Structure and Content (Content Knowledge)

- What is the Instructor and students doing? What else is happening relevant to my study?
- Does the Instructor reflect on the previous day's lesson? Was the day's lesson introduced?
- How are the instructions to the students for the lesson?
- How does the Instructor demonstrate understanding of the content being taught?

- How are the interactions between the Instructor and students in the lesson?

What you see	What you think works well/less well

Technology use to support content (Technological Content Knowledge- TCK)

- What technological tools were used in the lesson?
- How are the technological tools being used and was it planned or unconsciously?
- Did both the instructor and students use the tools? How and why?
- How does the technological tools influence the lesson delivery?
- Are there challenges using the tools by the instructor?

What you see	What you think works well/less well

Technology use to support teaching strategies (Technology Pedagogical Knowledge - TPK)

- What teaching strategies were used to deliver the lesson?
- How suitable were the specific technologies for the teaching strategies during the lesson delivery?
- How does the technologies enhance interactions in the class.

What you see	What you think works well/less well

Application of Technology, Pedagogy, and Content Knowledge - TPACK

- How does the instructor create a link between pedagogical strategies, technological tools and the topic being delivered?
- How does the combination of technology and pedagogy assist student to understand the content?
- Do the use of technology allow students to practice critical thinking?

What you see	What you think works well/less well

APPENDIX G: FOCUS GROUP DISCUSSION GUIDE

FOCUS GROUP DISCUSSION GUIDE

My name is Victoria Nepembe. Thank you for agreeing to meet with me today. The purpose of our meeting is to discuss technological infusion affecting the education system's teaching and learning process. This is because you must possess technological pedagogical content knowledge to integrate technology in teaching. We will engage in a focus group discussion, which is a technique where a researcher combines a group of individuals to discuss a specific phenomenon and extract from their various personal experiences, beliefs, perceptions, and attitudes through minimal interaction. In this study, it is how you integrate technology in teaching and develop your TPACK. There are no right or wrong answer in the Focus Group Discussion and I encourage you to feel free to discuss and share your insights on how you integrate technology in teaching. Technology has been and is moving at a faster pace, so I am aware that there are many ideas to be discussed and shared. I will be moderating the discussion and ensure that we exhaust all the points. In addition to being a moderator, I will also be taking notes of your discussions as well as audio recording so that I grasp exactly what was discussed. The information discussed will be kept confidential and for research purpose only and that participants' details such as names will not be revealed in the notes and the research report. Additionally, you are free to withdraw from the FGD. Since the discussions will be recorded, I request that you give consent by signing the consent form for participation and audio recording below:

INFORMED CONSENT FORM: FOCUS GROUP DISCUSSION WITH AUDIO RECORDINGS

I will be asking you some questions for which there is no right or wrong answer. Only your views and opinions about technological pedagogical content knowledge is needed. I will be taking notes of our discussion as well as audio record at the same time. However, if you do not feel comfortable to be recorded, the audio cannot be used, and for parts to be excluded from audio recording, it can be switched off. You are also assured that your identity will be kept confidential and will at no time be revealed when transcribing the notes and audio recording. You are further assured that I am only allowed to keep the notes and audio recordings for up to 6 months after completion of my thesis, upon which all recordings should be wiped.

Please tick the following boxes to indicate that you have read and understood the information to participate in the research interviews:

- ☐ confirm that I have read and understand the subject information part of this form
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reasons and without adverse consequences
- ☐ I understand that all the information will be kept strictly confidential and no personal details such as names will be revealed
- ☐ I understand that the interviews will be note and audio recorded and that I am free to withdraw my consent to be audio recorded and/or for some parts thereof not be recorded
- ☐ I understand that all information notes and audio recorded will be deleted 6 months after completion of the thesis.

Please tick one of the following boxes to indicate whether you agree to participate in the research interviews:

- ☐ agree to take part in the research interviews without audio recordings
- ☐ agree to take part in the research with audio recordings
- ☐ not agree to take part in the research interviews with or without audio recordings

SIGNATURE: _____ DATE: _____

FOCUS GROUP DISCUSSION QUESTIONS

1. There are various emerging technologies which can be used for teaching. Which of those technologies do you use in your teaching and why?
2. Describe how have you integrated technology in your classroom and what informed such action/step?
3. When self-learning to teach using technology in your context, what TPACK sources did you focus on and why?
4. Explain what self-learning activities did you undertake which may have helped you to integrate technology in teaching?
5. Explain what challenges did you experience when teaching using technology and how did you overcome them?
6. Describe the support you required to integrate technology. Explain why you needed such support and from where?

7. Based on your experiences of teaching with technology, how different would your TPACK be and why?

APPENDIX H: RHODES UNIVERSITY ETHICS CLEARANCE



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/>

22 June 2023

Dr Clement Simuja

Education Department

C.Simuja@ru.ac.za

Dear Dr Clement Simuja and V Shiimi

Your application Evolution of Instructors' TPACK in Vocational Training Centres: A multi-case study, 2023-7328-7725 has been reviewed by the Education Faculty Research Ethics Committee [EF-REC].

Ethics approval has been granted pending the required Permission Letters being obtained from the organisation(s) listed in your application.

The Executive Director, The Ministry of Higher Education, Technology and Innovation

The Executive Director, Namibia Training Authority

Your application can be downloaded as a PDF version and forwarded with your permission letter request. Please refer to the Applicant User Guide for how to do so.

Please forward the required permission letter/s, once received, to the EF-REC Chair (E.Rosenberg@ru.ac.za) and to the Education Research Ethics Coordinator (ethics-committee@ru.ac.za) in order for your approval to be finalised.

Sincerely

Professor Eureka Rosenberg

Chair: Education Faculty Research Ethics Committee

APPENDIX I: RHODES UNIVERSITY HIGHER DEGREE APPROVAL



Education Higher Degrees Committee
Chair
Education Department, Grey Street, Grahamstown/Makhanda, 6139, South Africa
PO Box 94, Grahamstown/Makhanda, 6140, South Africa
t: +27 (0) 46 603 8315
e: dean.education@ru.ac.za

22/06/2023

Victoria Shiimi

Prof NhlaNhla Mpofu, Dr Clement Simuja

7328

Education Department

Dear Victoria Shiimi

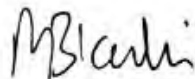
Re: Evolution of Instructors' TPACK in Vocational Training Centres: A multi-case study-7328 Jun 2023

This letter confirms that the Higher Degree Committee has approved your research proposal, for the degree of Education low/med risk in Education in the Faculty of Education titled: Evolution of Instructors' TPACK in Vocational Training Centres: A multi-case study

Please note that the reviewers did have some comments about the proposal, attending to these will serve to strengthen the study. Please discuss their feedback with your supervisors before proceeding with your study.

You will need ethical clearance from the Education Faculty Ethics Committee before you can begin your research. The ethics review process is underway and you will receive a separate outcome notification from the Chair: Education Faculty Ethics Committee.

Sincerely,



Prof Margaret Blackie

Chair: Education Higher Degrees Committee

Associate Professor: Centre for Higher Education Research, Teaching and Learning

cc. Ms Victoria Nepembe

APPENDIX J: NTA PERMISSION LETTER TO CONDUCT RESEARCH

Enquiries: Tuwillika Shilongo
Tel.: +264 61 2078155
Email: tshilongo@nta.com.na



05 July 2023

Ms Victoria Nepembe
Mobile: +264811492241
E-mail: ndshiimi@gmail.com

Dear Ms Nepembe,

REQUEST FOR CONSENT TO CONDUCT A STUDY IN THE CONTEXT OF EVOLUTION OF INSTRUCTORS' TPACK IN VOCATIONAL TRAINING CENTRES: A MULTI-CASE STUDY.

Your correspondence, dated 23 June 2023, addressed to Mr. Amon Haufiku, bears reference.

Kindly be informed that Namibia Training Authority (NTA) had reviewed the study instrument on "*Evolution of instructors' TPACK in Vocational Training Centres: A Multi-Case Study*" and see no harm in allowing you to carry on with your study, provided that you share the outcome of the study with the NTA. It is substantial to observe ethical practices during the study. Permission, is therefore, hereby granted to conduct your research as per the request.

Yours Sincerely,


Mr. Indongo Indongo
Manager: Research and Planning Division



APPENDIX K: NAMCOL PERMISSION LETTER TO CONDUCT RESEARCH



Jetu Jama Centre, Independence Avenue, Windhoek
Private Bag 15008, Katutura, Windhoek
Tel: + 264 61 320 5111, Fax: + 264 61 216 987, www.namcol.edu.na

08 August 2023

Ms. Victoria Nepembe
P O Box 97507
Maerua Mall
Windhoek
NAMIBIA

Dear Ms. Nepembe

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT NAMCOL

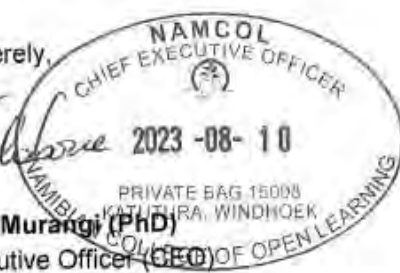
Reference is made to your request received on 24 July 2023 regarding the above subject matter. I have the pleasure to inform you that your request to conduct research on ***"Evolution of Instructors' TPACK in Vocational Training Centres: A multi-case study"*** towards your studies is hereby acknowledged and positively considered.

However, you are required to submit the following to the College upon completion of your studies, the objectives, population and methods to be used, for the study, consent form and a copy of your research report.

I wish you all the best with your academic career.

Yours sincerely,


Heroldt V. Murangi (PhD)
Chief Executive Officer (CEO)



APPENDIX L: WVTC PERMISSION LETTER TO CONDUCT RESEARCH

NAMIBIA NATIONAL TRAINING ORGANISATION (PTY) LTD

Trading as:

Windhoek Vocational Training Centre

21 August, 2023



Private Bag 13334
P.O.Box 3771
WINDHOEK
NAMIBIA
Tsukoe //Gowases Street
Khomasdal
Tel (00264) 61 211742
Fax (00264) 61 212379

Ms. Victoria Nepembe
P.O. Box 97507
Maerua mall
Windhoek

Dear Ms. Nepembe

Request for permission to Conduct Research

This is with reference to your letter received on 21 August 2023 regarding institutional permission for your research project. I am glad to announce that you have been granted permission as per the information presented in your request letter.

This also serves as assurance that the researcher will observe the participants' privacy, confidentiality, and anonymity. Kindly ensure that these requirements are followed in the conduct of this research project.

We wish you success with your research project.

Yours Sincerely,

A handwritten signature in black ink, appearing to read 'Polli Andima', is written over a horizontal line.

Mr. Polli Andima
Centre Manager



CENTER MANAGER
WINDHOEK VOCATIONAL TRAINING CENTRE
P / BAG 13334
WINDHOEK, NAMIBIA
TEL: (061) 211742
FAX: (061) 212379 / 210485

APPENDIX M: CERTIFICATE OF LANGUAGE EDITING

Nikki Watkins

Editing/proofreading services

Cell: 072 060 2354

E-mail: nikki.watkins.pe@gmail.com

8 February 2025

To whom it may concern

This letter confirms that I have copy-edited and proofread the PhD thesis

**EVOLUTION OF INSTRUCTORS' TECHNOLOGICAL PEDAGOGICAL CONTENT
KNOWLEDGE IN VOCATIONAL TRAINING CENTRES: MULTI-CASE STUDY**

by

VICTORIA NEPEMBE



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Associate Member

Membership number: WAT003
Membership year: March 2023 to February 2024

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www.editors.org.za



Mobile: +264 81 129 8346

E-Mail: ces@cesnam.com

09 July 2024

TO WHOM IT MAY CONCERN

CERTIFICATE OF LANGUAGE EDITING (*PhD Thesis*)

This is to **certify** that I edited Ms Victoria Nepembe's *Doctoral Thesis* for Rhodes University, Faculty of Education, entitled "Evolution of Instructors' Technological Pedagogical Content Knowledge in Vocational Training Centres: Multi-Case."

Truly,

Prof Fred Opali
Director & Trainer
Cornerstone English Services
(CES)

E-Mail : ces@cesnam.com

Mobile: +264 81 129 8346