THESIS SUBMISSION

Case Studies on South African Preservice Teachers' Experience of Blended Learning in Technology Education

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DECLARATION

I, Zaynab Mobara-Links, declare that the thesis, Case Studies on South African Preservice Teachers' Experience of Blended Learning in Technology Education, and the interrelated, publishable articles submitted for the qualification of Doctoral degree (PhD) in Education at the University of the Free State is my own, independent work.

All the references that I used have been indicated and acknowledged by means of a complete reference list.

I further declare that this work has not previously been submitted by me at another university or faculty for the purpose of obtaining a qualification.

Z Mobara-Links ..... 13-Feb-2025 .....

SIGNED DATE

ABSTRACT

This research explores the perceptions, understanding, engagement, and experiences of third-year Technology Education preservice teachers who participated in a blended learning approach at a South African higher education institution. Their perceptions and experiences play an important role in uncovering the effectiveness of the approach in a practical-based subject. The study analysed the literature on Technology Education, blended learning, and information and communications technology (ICTs), to understand the factors influencing the effective implementation of blended learning approaches. The blended learning approach employed combined face-to-face and online teaching and learning, as well as a portfolio of research evidence to enhance preservice teachers' engagement in the learning outcomes. The study used a multiple-case study designs as the research design. Furthermore, the Technology Acceptance Model and the Community of Inquiry framework were used as the theoretical frameworks. Data were collected through a survey, document analysis, and open-ended interview questions. The data were analysed using descriptive and thematic analysis methods. The results showed that preservice teachers had a positive perception of the blended learning approach employed and reported various benefits, including increased creativity, increased collaboration and problem-solving, and active engagement in hands-on experiences. The study also identified the challenges of the blended learning approach, such as limited time, limited access to applicable resources and venues, and some limited knowledge on where to gain additional information. The study concludes by theorizing a conceptual framework developed from the findings and recommends that blended learning is one promising teaching and learning approach for Technology Education preservice teachers in a South African higher education institution.

Keywords: blended learning, design process, preservice teachers, teacher training, Technology Education

LIST OF PAPERS PRESENTED AT CONFERENCES

Name of organization	Title	Place	Date
University of the Free State Institutional 3 Minute Thesis	Engaging Technology Education Preservice Teachers in a Blended Learning Approach	Bloemfontein	11 October 2024
Faculty of Education 3 Minute Thesis	Engaging Technology Education Preservice Teachers in a Blended Learning Approach	Online	27 September 2024
UFS Learning and Teaching Conference Theme: Enhancing the Quality of Blended Learning and Teaching within the UFS Context	Blended Learning in Technology Education: Engaging Preservice Teachers in the Design Process Category: Innovating my curriculum through the use of technology and/or online tools	Bloemfontein	18 September 2024
UFS Learning and Teaching Conference Theme: Enhancing the Quality of Blended Learning and Teaching within the UFS Context	Understanding the Experiences of Technology Education Preservice Teachers in Blended Learning Category: Innovating my curriculum through student engagement and/or motivation	Bloemfontein	17 September 2024

32nd Conference of The Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)	Technology Education Preservice Teachers' Perceptions of Blended Learning	Namibia	16 – 18 January 2024
5th Annual Postgraduate Research Conference	Understanding the Experiences of Preservice Teachers in Blended Learning in a Technology Education Course	Bloemfontein	06 – 07 October 2023
4th Annual Postgraduate Research Conference	Technology Education Preservice Teachers' Perception and Experiences of Blended Learning in a University Context	Bloemfontein	07 – 08 October 2022

LIST OF ACHIEVEMENTS

Name of organization	Title	Award
Faculty of Education 3 Minute Thesis	Engaging Technology Education Preservice Teachers in a Blended Learning Approach	Second Place Award
UFS Learning and Teaching Conference Theme: Enhancing the Quality of Blended Learning and Teaching within the UFS Context	Blended Learning in Technology Education: Engaging Preservice Teachers in the Design Process Category: Innovating my curriculum through the use of technology and/or online tools	First Place Award

DEDICATION

I dedicate this thesis to:

My son, **Yaghya**. Your existence motivated me to complete this thesis, and I hope that I motivate you to do the same one day. Seek knowledge from the cradle to the grave, my son. I know you will make us proud in all your educational pursuits.

My loving husband, **Kayan**. You are an exceptional and incredibly intelligent person. You were, and remain to be, my pillar of strength and guidance. You supported and motivated me through the many ups and downs. I am forever grateful for your patience and your sacrifices. Always and forever, my love. *Always and forever.*

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LIST OF ABBREVIATIONS AND ACRONYMS

4IR	Fourth Industrial Revolution
AJRMSTE	African Journal of Research in Mathematics Science and Technology Education
B.Ed.	Bachelor of Education
CAD	Computer Aided Design
CAPS	Curriculum Assessment Policy Statement
CoI	Community of Inquiry
CUT	Central University of Technology
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
FET	Further Education and Training
eLET	e-Learning and Educational Technology
HEI	Higher Education Institution
HEIs	Higher Education Institutions
ICT	Information and communications technology
ICTs	Information and communication technologies
IDMEC	Investigate, Design, Make, Evaluate, Communicate
ITEA	International Technology Education Association

JTE	Journal of Technology Education
LMS	Learning Management System
PiE	Perspectives in Education
SPU	Sol Plaatje University
STEM	Science, Technology, Engineering, and Mathematics
TAM	Technology Acceptance Model
UFS	University of the Free State
UKZN	University of KwaZulu Natal

CLARIFICATION OF KEY CONCEPTS

The following terms will be defined by the researcher to assist in understanding the key operational terms used in this study.

Blended learning: An approach where teaching and learning practices take place in both an online setting (asynchronous) and in a face-to-face setting (synchronous). Refer to section 1.2 for a detailed explanation.

Community of Inquiry (CoI): a theoretical framework developed to understand the experiences of online and blended learning approaches. Refer to section 2.3.3 for a detailed explanation.

Design process: The “backbone of the subject” (DBE, 2011:12). The design process refers to the application of a systematic process aimed at developing solutions to problems. The process involves investigating the problem, identifying solution(s) through design, planning, making and evaluating, and communicating. Refer to section 2.2.4 for detailed explanation.

Graphical communication: Communication using visual elements, such as drawings/sketches, pictures, icons, and photographs, to exchange information, express ideas, and concepts, and convey opinions and desires. As noted by Rojas-Sola (2021), graphical communication provides graphic expression to the design process and is becoming increasingly popular.

Higher education institutions (HEIs): Universities, colleges, and professional schools that provide instructional services to individuals in fields, such as education, theology, law, music and arts, health, business, and the humanities.

Information and communications technologies (ICTs): Electronic devices, such as computers, mobile devices, and other electronic devices that allow individuals to engage in teaching and learning activities online. These activities include developing, designing, delivering, sharing, and/or receiving information and content for various reasons, such as educational purposes. Such information and content include PowerPoint slides, PDF documents, audio-visual recordings, videos, learning activities, and additional resources. Refer to section 1.2 and 2.2.1 for additional information.

Practical-based activities: Learning that takes place through practical experimentation. It includes tasks that develop skills, such as technological literacy, critical thinking, problem-solving, and professional conduct, over a prescribed period. Further insight into Technology as a practical-based course can be found in section 2.2.3.

Learning Management System (LMS): Blackboard Learn is used as the LMS. On this platform, the instructor can prepare and present recorded or live lectures, deliver course notes, create assessments, such as tests, assignments, and rubrics, and create discussion forums, as well as allowing for evaluation and feedback. The platform also allows for monitoring of preservice teacher engagement in the course, such as the frequency of when preservice teachers accessed content and recordings, or whether they were active in the online course. Refer to section 2.2.1 and Article 1 for additional information on Blackboard as the LMS in this study.

Preservice teachers: Prospective teachers who are currently enrolled in teacher education programmes as undergraduate or postgraduate students. In the South African context, preservice teachers include students who are pursuing Bachelor degrees in Education (BEd); or students who are already in possession of another Bachelor degree (e.g., a Bachelor of Science), and who are enrolled in a one-year teacher-training programme, such as a postgraduate diploma or certificate in education (PGDE/PGCE).

STEM: An umbrella term used for the grouping of Science, Technology, Engineering, and Mathematics courses.

Teacher educators: Academics, lecturers, and/or teachers at higher education institutions who engage in teaching and learning activities for prospective teachers. Teacher educators initiate, guide, and support teacher learning, and undertake research, community engagements, and the supervision of postgraduate students.

Technological literacy: (i) The technology of artifacts; (ii) the knowledge; (iii) the activities, and (iv) aspects of humanity. Furthermore, the International Technology Education Association (ITEA, 2003:10) refers to technological literacy as “the ability to use, manage, evaluate and understand technology”.

Technology: The application of engineering, scientific, and technological knowledge. Furthermore, it refers to the use of knowledge, skills, and resources to meet human needs and wants, and to recognise and develop practical solutions for everyday problems. Refer to section 2.2.3 for further insight.

Technology Acceptance Model (TAM): a theoretical framework that provides insight into how users accept and use technologies. Refer to section 2.3.1 for additional information.

Technology Education: The learning domain that seeks to develop knowledge, skills, and processes related to technology. It includes the application of technological processes (i.e., investigating, designing, developing, making, and evaluating) to products, processes, and systems, while considering the social and environmental impacts of doing so. Refer to section 2.2.3 for further insight.

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SECTION A: CHAPTER 1
INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

Student experience is a crucial indicator of the effectiveness and satisfaction with the pedagogies employed. It directly influences learning outcomes and student engagement as they are trained to communicate, gain knowledge and skills, and engage in activities for their success. Since the late nineteenth century, Higher Education Institutions (HEIs) have provided formalized training (Arbo & Benneworth, 2007; Brand, 1940; Hoque & Abdullah, 2021; Miceli, 1977) These institutions continuously evolve and adapt the strategies and tools used to produce graduates. Thus, understanding how students are prepared and trained to excel in life is crucial. Additionally, researchers agree that educational programmes must keep up with modern advancements in pedagogy and instructional tools (Chomunorwa, Mashonganyika, & Marevesa, 2023; Mabidi, 2024; Mapotse & Gumbo, 2012; Theodorio, Waghid, & Wambua, 2024). This highlights the need for continuous innovation and adaptation to ensure that students are well equipped for the evolving educational landscape. One such significant advancement in education is the introduction of blended learning approaches.

Blended learning is the combination of online and face-to-face activities that offer a flexible and effective approach to teaching and learning (see section 1.2). Research on the implementation of blended learning began in earnest in the early 2000 (Cooney et al., 2000). Accordingly, the question of how blended learning impacts teaching and learning environments continues to gain traction (Dziuban, Graham, Moskal, Norberg, and Sicilia, 2018). Furthermore, the approach had gained significant attraction in the year 2020, when the Covid-19 pandemic brought about abrupt changes in educational approaches. This resulted in a widespread adoption of online and blended learning activities to control the spread of the virus. In the context of the Fourth Industrial Revolution (4IR), digital literacy and technological proficiency have become essential skills that prepare students for the demands of the modern age (Pandey, 2023). As such, blended learning is now considered the new normal in teaching and learning strategies (Muhuro & Kangethe,

2021). Many institutions have adopted blended learning as their primary mode of teaching, ensuring student involvement in the process (Achahbar & Khoumssi, 2023). However, as noted by Anthony, Kamaludin, Romli, Raffei, Phon, Abdullah, & Ming (2020), limited information is available on (i) factors and constructs relating to the adoption of blended learning, and (ii) practices involved in the implementation of blended learning. In relation, very few studies focus on the implementation of blended learning in practical-based courses, such as Technology Education (Mulaudzi, du Toit, & Golightly, 2023). Hence, it becomes imperative to unpack and understand blended learning offerings and gain better insight into students' expectations and experiences (du Toit & Pool, 2020). This understanding is particularly crucial in Technology Education, where creating more effective, inclusive, and adaptable learning environments enhance technological and digital literacy skills.

Furthermore, Technology Education is recognized as a subject that provides foundational skills and knowledge for vocational training, emphasizing hands-on experience and the development of good work habits (Bierhoff & Prais, 1993; Makwanise, 2023; Nani & Sibanda, 2019). Thus, addressing this gap becomes necessary, as practical-based courses like Technology Education, require innovative approaches to effectively integrate online and face-to-face learning. Many studies have highlighted the need for integrating blended learning in practical-based courses (Puspitasari, Herlina, & Suyatna, 2020; Rachmawati, Setyaningrum, & Retnawati, 2019) and report on the benefits of such an integration. However, limited research is available on blended learning in Technology Education as a practical-based course. It is further noted that blended learning, in practical-based courses, is challenging to teach online, emphasizing the need to approach and overcome such challenges (Cavus & Ibrahim, 2007; Maksimović, 2017; Chang & Lee, 2022). Therefore, this study aims to explore preservice teachers' experiences of blended learning in a Technology Education teacher-training programme.

Technology Education was chosen because it engages preservice teachers in theoretical and practical course work. This dual approach ensures that preservice teachers not only understand the technological concepts, but also know how to apply them in real-world situations through the design process. Understanding their

engagement in a blended learning approach is crucial for effective teaching and learning for the development of a technologically literate society. More specifically, to understand these experiences, the researcher evaluated the facilitation of blended learning activities in a third-year led course at one South African HEI. The third-year preservice teachers were purposefully chosen to provide critical insights into the blended learning approach as they had not previously engaged in a blended learning approach within Technology Education.

Continued within Section A: Chapter 1, the researcher provides background information and defines the study's problem statement to contextualize its focus. Further, the research questions, aims, and objectives are outlined, guiding the study's focus. The anticipated value of the research, along with its delimitations and limitations, is also explained. The chapter concludes with an outline of the chapters in the study.

1.2 BACKGROUND

Blended learning is a teaching and learning approach that combines online and face-to-face activities (Ayob, Daleure, Solovieva, Minhas, & White, 2023; Fisher, Bushko, & White, 2017; Naidoo & Singh-Pillay, 2024). The terms digital learning, e-learning, and virtual learning are often used interchangeably with reference to blended learning. Balfour, van der Walt, Spamer, and Tshivhase (2015:2) noted that institutions have "various forms of non-traditional teaching and learning," which brought about the application of virtual learning practices, including blended learning approaches. HEIs have recognized the strengths of blended learning and have adapted their delivery methods accordingly (Ma'arop & Embi, 2016).

In South Africa, many higher education institutions (HEIs) and policy makers advocate for blended learning. This is evident in the White Paper for Post-School Education and Training document which highlights the need and importance of diverse modes of teaching to improve the quality of education (DHET, 2013); the Open Learning Policy Framework for Post-School Education and Training which emphasized the government's commitment to blended and open learning to increase accessibility (DHET, 2017); the UFS Learning and Teaching Strategy 2019–2024 which addresses the need

for 21 century skills (UFS, 2019); e-Learning and Educational Technology (eLET) which encourages the use of ICTs and online environments (CUT, 2022); E-Learning which initiated the transitions between face-to-face, online, and blended learning environments to ensure continuity and quality education (SPU, 2020), and UKZN Technology Enhanced Learning which aims to improve the teaching and learning experiences (UKZN, 2018), to name a few. Therefore, South African HEIs are generally expected to align with the policy documents and integrate quality-assured blended learning approaches.

Initially, blended learning was introduced to provide quality education to those who are unable to attend or afford face-to-face classes in a variety of programmes (Balfour et al., 2015; du Toit & Pool, 2020). Despite its growing prominence since the late 20th century (Bonk & Graham, 2006; Cooney et al., 2000; Ketsman, 2020; Vo, Zhu, & Diep, 2020), little is known about its adoption in teacher education programmes at HEIs both locally and internationally (Anthony et al., 2020; Buhl-Wiggers, Kjærgaard, & Kasper Munk, 2023; Buluma & Walimbwa, 2021; Menon & Motala, 2022). More specifically, little is known about blended learning approaches implemented in Technology Education (Mulaudzi et al., 2023).

The onset of the pandemic required academic programmes to shift abruptly from face-to-face to an online learning environment. As life resumed into a new normal, with stricter health measures, the potential impact of online and blended modes of teaching is evident. While blended learning offers many strengths, it also presents challenges. McDonald (2012:6) argues that current students tend to experience isolation due to “large amounts of electronic correspondence, limited instructor interaction, and limited interaction with other students”. It becomes necessary to thus understand how these recent pedagogical changes within HEI programmes are experienced by students, especially in the practical-based courses that have traditionally relied on face-to-face pedagogy.

It is often reported that blended learning approaches primarily focus on “theoretically founded learning areas, with less attention directed toward fundamentally practical learning areas” (Best & MacGregor, 2017:201). This gap is what prompted the

need to report on the preservice teachers' experiences of what is considered best practice for carrying out blended learning in Technology Education.

Practical learning areas are traditionally the most difficult to teach online as they require the use of laboratories (Cavus & Ibrahim, 2007; Maksimović, 2017). This is supported by Chang and Lee (2022), who state that practical, hands-on experiences cannot be offered online, thus encouraging the research on the implementation of blended learning in the practical based courses. Recently, however, reports have emerged of practical-based courses – Sciences, Technology, Engineering, and Mathematics (STEM) – being engaged in online teaching and learning practices.

Technology Education, as a course, was chosen for this study because it contains both practical and theoretical elements in its teaching and learning activities. The subject aims to develop graphical communication skills and practical skills, with the ability to work safely with appropriate tools needed to engage effectively in the design process, thus developing technological literacy. Practical-based activities are imperative for training engineers, artisans, and technicians who contribute to fulfilling the technological needs of society (DBE, 2011). These educational objectives can be challenging to achieve as HEIs move towards blended learning (Wiebe, Brandoff, & Shreve, 2011; Best & MacGregor, 2017). Understanding how blended learning activities are experienced by preservice teachers provides valuable insight into overcoming these challenges.

Furthermore, the information and communications technologies (ICTs) used in blended learning need to be identified and reported on. As stated by Jita (2018:2), not "enough attention […] has been paid to the preparation of teachers to use ICT tools for teaching." Using ICT in and for blended learning is important for developing technological literacy. Preservice teachers' engagement with various ICTs for teaching, learning, research, and communication, and to reach course outcomes must be understood. Thus, the preservice teachers' experience of blended learning, in the context of Technology Education, is explored in this research study.

As a teacher educator and postgraduate student involved in the teaching, learning, and training of blended learning approaches, the researcher noticed variations in how preservice teachers experience and implement blended learning. These approaches

range from using various ICTs to support teaching and learning to the manner in which information is shared. The discrepancy in the ICTs used to prepare teaching and learning materials for theoretical and practical activities was also noted. This research arose out of an interest in what is considered best practice for implementing various blended learning approaches in a practical-based course and how these approaches are carried out effectively to ensure the achievement of Technology Education course outcomes, as well as a concern for developing competent and technologically literate future teachers.

The study is situated within a South African Higher Education Institution (HEI) in the Free State Province. The multiple-case study design comprised two cases, both centred on a Technology Education course within the Faculty of Education. More specifically, the study focused on the third-year Technology Education preservice teachers who registered for the course in the years of 2022 and 2023. This course was delivered both online and face-to-face in designated classrooms and technology laboratories. However, this study focused on selected participants within this practical-based course at the time when blended learning approaches were implemented as the preferred teaching and learning approach.

1.3 PROBLEM STATEMENT

As HEIs increasingly offer blended learning curricula that integrate remote and face-to-face teaching, this approach provides opportunities for increased student support, satisfaction, ease of access to information, and flexibility. Blended learning can reduce the need for specified locations, decrease time constraints, and is cost-efficient, with the potential for new revenue sources not possible through contact teaching (Ndlovu, Mbatha, & Mzisa, 2020). Although blended learning offers many benefits, much remains to be explored about how it is experienced in practical-based courses like Technology Education.

Van Schalkwyk (2021) highlights that HEIs still have much to learn about the efficiencies and effectiveness of new teaching and assessment modes. Similarly, Joksimović, Kovanović, Skrypnyk, Gašević, Dawson, and Siemens (2015) note that limited evidence provides insight into various blended learning approaches impacting

course achievement. Furthermore, Janse van Rensburg and Oguttu (2022) emphasize the need to investigate how blended learning is adopted by HEIs in South Africa and across Africa. Given that blended learning can be implemented in many ways depending on the institution and course content, there is indeed a need to investigate the designs and adoption of different blended learning modes offered in various courses at different institutions (Janse van Rensburg & Oguttu, 2022).

The onset of the novel coronavirus acted as a catalyst for encouraging full online learning and blended learning approaches in South African HEIs, amplifying existing gaps within these approaches. As noted by van Schalkwyk (2021), students at HEIs responded differently to these barriers, but overall, performed better in online learning environments. This led the researcher to question how preservice teachers' capabilities are developed and assessed in blended learning approaches in Technology Education.

Furthermore, as noted by Pappa, Georgiou, and Pittich (2024), Technology Education is often not given sufficient attention or emphasis compared to other STEM subjects in research generally. De Vries (2000) highlights that the subject is struggling for its position in the school curriculum. This is further supported by Pappa (2024), who states that there is a lack of uniform standards across various educational levels due to this limited attention. Additionally, the practical aspect of Technology Education is often neglected (Pappa, 2024). Mapotse (2017:685) makes a strong statement, asserting that;

If teachers are not equipped to teach Technology Education subject nationally and internationally, the continent of Africa will continue to bear the brunt of unsavoury results.

In addition, Mapotse (2017) and Gumbo (2020) note gaps in the pedagogy and content knowledge of the subject, with Gumbo (2020) further stating that there is a scarcity of professional development in Technology Education. This perception and experience formed the basis for choosing Technology Education for this study. The subject aims to equip students with the skills and knowledge essential for navigating and contributing to a technologically literate and ever-advancing society. It is important that teacher education prepares students to understand and teach fundamental topics effectively, both theoretically and practically.

As blended learning approaches gain significant attention in education, there is limited research on Technology Education preservice teachers' perceptions of blended learning. By examining these perceptions, understandings, engagements, and experiences of preservice teachers, this study aims to fill the gap in the literature and provide insight into teacher education programmes within the Technology Education field.

1.4 RESEARCH QUESTIONS

The primary research question of the study is as follows:

> How do South African preservice teachers experience blended learning in a Technology Education class?

The following serve as secondary research questions:

1. How do Technology Education preservice teachers perceive and understand blended learning within a university context?
2. How are preservice teachers engaged in blended learning Technology Education courses in South Africa?
3. What are preservice teachers' perceived impacts of blended learning in Technology Education courses?

1.5 AIMS AND OBJECTIVES OF THE STUDY

This study aimed to explore how preservice teachers experience blended learning in a Technology Education class. The study also focused on developing a conceptual framework by reporting on preservice teachers' perceptions and expectations of the teaching and learning activities carried out in blended learning approaches, and to outline common patterns in their experiences.

The specific objectives that were addressed by the study are as follows:

1. To explore the perceptions and understanding of the preservice teachers in implementing blended learning approaches.

2. To examine patterns of practice in engaging preservice teachers with blended learning in a Technology Education class.
3. To evaluate the perceived impacts of blended learning on preservice teachers in Technology Education courses.
4. To develop theoretically informed and empirically based explanations of the practices of blended learning and how it is experienced by preservice teacher education students at different universities in South Africa.

1.6 SIGNIFICANCE OF THE STUDY

The study anticipates contributing to the existing literature on blended learning in Technology Education. More specifically, the study recommends a conceptual framework derived from the findings and designed by the researcher. It is further anticipated that this research will offer a deeper understanding of how blended learning can be effectively implemented in Technology Education, but more specifically within teacher training programmes. Additionally, it can help educators design and implement blended learning approaches that are more engaging for students, taking ICTs into consideration for specific purposes. These purposes include the use of ICT for learning, research, and communication.

Furthermore, the study anticipates contributing to literature by offering practical recommendations for enhancing the teaching and learning practices in various STEM fields generally. Moreover, by examining preservice teachers' perceptions and experiences of blended learning in a Technology Education course, the study provides critical insights from a South African perspective that may benefit multiple stakeholders involved in this subject. These stakeholders include students, preservice teachers, in-service teachers, government and policy makers, professional bodies, and publishers. It is anticipated that students and preservice teachers will benefit from the enhanced learning experiences, which leads to better engagement, achieving learning outcomes, deeper understanding of content and practice, and effective integration of ICTs in their future teaching endeavours. In-service teachers can also benefit from the study findings as it provides insight into how to design courses in a blended learning environment.

Additionally, government, policy makers, professional bodies, publishers can gain significant knowledge and understanding on how to guide the development of policies that support and promote the integration of ICTs in Technology Education courses.

The findings also provide leverage to produce resources and learning material that align with best practices in blended learning environments which support the advocation of blended learning as outlined in section 1.2, as it is envisaged that the study will contribute to the endeavours of HEIs to effectively engage preservice teachers in 21st-century technologies so that they can contribute, locally and globally, to society (UFS, 2020). The study will identify how ICTs are used in blended learning for practical-based courses. The trends found in such applications will be discussed to contribute further to the literature on blended learning approaches.

1.7 DELIMITATIONS OF THE STUDY

Defining the research serves to make the research topic manageable from a practical perspective. The selected research site and participants were close to where the researcher is permanently based and is thus a contributing factor to easing the data collection processes. This makes it easier to gain valuable insight into and understanding of the blended learning approach in a third-year Technology Education teacher-training programme. There were no prerequisites for participation as the race, gender, and age of the participants did not influence the request to participate in this study. This empirical study was limited to two cases the constituted towards a multiple-case study design that investigated the implementation of blended learning in Technology Education.

The data collection tools used were limited to a document analysis, a survey, and open-ended interview questions. The study selected third-year Technology Education preservice teachers who participated in the document analysis and survey during the August– October period in 2022. In addition, third-year Technology Education preservice teachers participated in the open-ended interview questions in August 2023. The results of the data collected from a single institution may be applied with caution to other preservice teachers who graduate, for example:

1. With similar teacher education programmes developed for practical learning areas;
2. From different HEIs in the same country, with similar strengths and weaknesses in competence when implementing blended learning; and
3. From any other country with HEIs that do not stipulate the evidence of the competence of blended learning in practical learning areas as a requirement for graduating students.

1.8 OUTLINE OF THE THESIS

The report is presented in the form of an article-based thesis with the following sections instead of traditional chapters.

Section A

Chapter 1: Introduction and background to the study

Section A is divided into three chapters. Chapter 1 provides an overview of what to expect from the study. It provides the reader with an introduction, background, and problem statement for the study to contextualize the focus and narrow the gap. The chapter further introduces the research questions, aims, and objectives that guided the study. As an important aspect of any study, this chapter outlines the significance of the study and who would potentially benefit from it. Furthermore, the delimitations outline the boundaries of the study and give focus by narrowing down the research to a manageable scope. Thereafter, chapter 1 then concludes with a brief discussion on the outline of the thesis.

Chapter 2: Literature Review and Theoretical framework

This chapter offers a comprehensive literature review, detailing blended learning, the use of ICTs, and their implementation in STEM Education. It aims to provide readers with a thorough understanding of how blended learning is applied in practical-based courses. The chapter then explores Technology Education as a subject, the design process—

which is considered the backbone of Technology—and the role of Technology in teacher education. Subsequently, the theoretical frameworks underpinning the study, specifically the Technology Acceptance Model (TAM) and Community of Inquiry (CoI) frameworks, are discussed in detail. The practical applications of these frameworks are then examined in relation to the study, followed by an outline of the relationship between the frameworks.

Chapter 3: Research methodology.

Chapter 3 focuses on the research design and methodology. The chapter begins by outlining the purposes of the study and recapping the research questions after the introduction. Thereafter, the research design and research paradigm are discussed. Moreso, a multiple-case study design and a pragmatic paradigm respectively. The chapter continues with the mixed-methods as a research approach before discussing the data collection, data analysis, and data interpretation processes. This entailed open-ended interview questions and document analysis which formed part of the qualitative approach. Data from the qualitative approach were analysed using thematic analysis. Furthermore, quantitative data from the surveys were analysed a-priori as it was adapted from an existing survey – the CoI survey. Furthermore, the data were analysed using Microsoft Excel and IBM SPSS Version: 29.0.0.0 (241) to draw meaningful conclusions and make informed decisions from inferential data.

Section B: Presentation of the three publishable articles

Three publishable articles are presented in this section, mainly inline with the major research questions proposed in this study.

1. Article 1: Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university.

   This article was developed to respond to the first research question which asks, “How do Technology Education preservice teachers perceive and understand blended learning within a university context?”. The intent is to explore and gain insight into several key aspects such as their perceptions, understanding, contextual factors, and impact on learning. To elaborate, the article aims to

understand the attitudes, beliefs, and opinions that preservice teachers hold about blended learning. This includes their overall impressions, perceived benefits, and potential drawbacks. Further, the article aims to assess the depth of knowledge and comprehension that preservice teachers have regarding blended learning in Technology Education. This involved exploring their grasp of blended learning concepts, methodologies, and best practices that could be employed in a practical-based course. In addition, by doing so, the researchers could evaluate how blended learning affects preservice teachers' learning outcomes, engagement, and overall educational experience. The researchers identified the African Journal of Research in Mathematics Science and Technology Education (AJRMSTE) as the most applicable journal to submit the article to. The article therefore followed the unique structure and guidelines of the AJRMSTE. Currently, the article is under review for a second submission.

2. Article 2: Profiling the engagement patterns of preservice teaching in a blended learning Technology Education class at a South African institution.

   Article 2 was developed to respond to the second research question which asks, “How are preservice teachers engaged in blended learning Technology Education courses in South Africa?”. The intent is to explore and understand preservice teachers’ engagement in a blended learning approach implemented in the Technology Education course. More specifically, the article explored their engagement in the design process, which guides how theoretical knowledge is applied practically. Furthermore, the article assessed their involvement in both online and face-to-face components of the course, and explored the use of digital tools, online platforms, and face-to-face resources. The article was submitted to the Perspectives in Education (PiE) Journal for review. The article therefore followed the unique structure and guidelines of the PiE article submission format. Currently, the article is still under review as feedback has not yet been received.

3. Article 3: Reported perceptions of preservice teachers on blended learning in a Technology Education class.

This article was developed to address the third research question which asks, “What are preservice teachers’ perceived impacts of blended learning in Technology Education courses?”. This article was guided by the Community of Inquiry (CoI) survey, and thus aimed to explore the perceived impacts through the lens of the CoI framework. More specifically, the article was guided by the teaching presence, cognitive presence, and social presence. As a result, the article aimed to understand how preservice teachers perceive the role and effectiveness of the instructor in a blended learning environment, their perceive ability to construct and confirm meaning through sustained reflection and discourse in a blended learning setting, and their ability to project themselves socially and emotionally in a blended learning environment. The findings were further analysed using inferential statistics to better understand preservice teachers perceived impacts of a blended learning approach in Technology Education and draw meaningful conclusions and make informed decisions. This article was developed according to the Journal of Technology Education (JTE) and followed the unique structure and guidelines of the article. The article was accepted with major corrections and has been revised accordingly. This included additional information and insight, and the inclusion of inferential statistics.

Section C: Conclusion

Chapter 4: Discussion of key findings, conclusion, and recommendations

The study concludes with section C which responds to the main research question, (i.e., How do South African preservice teachers experience blended learning in a Technology Education class?). The summary of the results is presented, along with the key findings of the study, and discussion on the contribution to scholarship. More specifically, a conceptual framework, which is derived from the findings and designed by the researcher is presented and theorized. Furthermore, the study draws the conclusions, and then makes recommendations for research, policy, and practice.

SECTION A: CHAPTER 2
LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

This study investigated the blended learning practices employed in a third-year Technology Education course. More specifically, the study reports on the perceptions, understanding, engagement, and experiences of the preservice teachers enrolled in the course. The chapter starts with a literature review on blended learning practices that seek to enhance the technological literacy of preservice teachers, with the intention of providing a conceptual basis for the study. Thereafter, the chapter continues with a discussion of the theoretical frameworks that underpin the study. More specifically, the Technology Acceptance Model (TAM) and the Community of Inquiry (CoI) theory which enabled the researcher to respond to the research questions, aims and objectives of the study.

2.2 LITERATURE REVIEW

A literature review serves to provide context to the research within a broader academic conversation. Within this study, this literature review section of the chapter provides literature of blended learning and the use of ICTs and blended learning in STEM education. The purpose of this is to provide a holistic overview of how blended learning is implemented in theoretical and practical based courses, and then narrow it down to Science, Technology, Engineering, and Mathematics Education. The literature is further narrowed down to Technology Education whereby the researcher presents a discussion of Technology, as the subject that underlines this study. Thereafter, the design process, as the backbone of Technology, is elaborated on to provide a sense of what it entails and how it is implemented within the South African Curriculum Assessment Policy Statement (CAPS) for Technology, and thus preservice teachers engage in the design process at a higher education level. Furthermore, an overview of Technology in the context of teacher education provides the reader with a sense of how preservice teachers are taught to teach Technology at a school level.

2.2.1 Blended learning and the use of ICTs

Blended learning can be simply defined as the combination of online and face-to-face learning. The terms “asynchronous” and “synchronous” learning have often been used to describe online and face-to-face learning respectively. However, Driscoll (2002:1) opines that blended learning can “mean different things to different people” as it can be implemented in varying magnitudes of web-based technologies, tasks and activities, ICTs, and pedagogical approaches. Bazelais and Doleck (2018) note that traditional teaching approaches have often been criticised as being ineffective for the teaching of a STEM courses. However, Lim and Wang (2016:3) recognise that even though the implementation of blended learning approaches may seem less complex than it is, “the effectiveness of blended learning depends highly on the context in which it is adopted and how it is implemented”. Therefore, there is a need to understand how a blended learning approach can be implemented in a practical-based course. Suggested by Best and MacGregor (2017:202), Technology Education “can be meaningfully embossed in both classroom-based and online learning environments”. There are various modes in which blended learning can be implemented. This includes the flex model, hyflex learning model, the rotation model, and the enriched virtual model. These modes are discussed below. Thereafter, the benefits and challenges of blended learning are highlighted; followed by the use of ICTs.

a) Blended learning modes

Flex Model

This model involves flexible learning both in and out of the classroom. The student will have control over the pace, place, and path of learning. As noted by Krismadinata, Verawardina, Jalinus, Rizal, Sukardi, Sudira, Ramadhani, Lubis, Friadi, Arifin, and Novaliendry (2020), the flex model relies on online delivery of content and instruction. Students are therefore flexible in terms of their learning. In a study done by Abdurahman and Ahmad (2022), the authors identified problems, such as low media utilisation; lack of

training; insufficient data or the use of too much data; insufficient network or low connectivity; low interaction amongst course participants, and disordered time allocation. This led to a lack of interest which resulted in poor experiences and low motivation. However, the authors also noted opportunities offered by the implementation of the flex model, such as the ability of the participants to explore online resources, so that their reliance on the teacher is minimised.

Hyflex learning

The word “hyflex” is derived from the term’s “hybrid” and “flexible” (Miller & Baham, 2018). This mode of blended learning provides students with an option to attend online sessions or face-to-face sessions, as these sessions will be offered simultaneously (Amirova, 2023). The expectation from students who attend online, or face-to-face classes are the same; and the learning material used in either of the classes are designed for both modes. As such, the design of hyflex learning needs to be well thought out as it can bring about unique challenges. These challenges include delays on the online session compared to the face-to-face session, data and network requirements, methodological and pedagogical methods employed, and fostering positive discussions (Miller & Baham, 2018; Moldez, 2024).

Rotation Model

This approach offers various sub-models, such as flipped classroom, individual rotation, station rotation, and lab rotation (Brooke, 2016).

- Flipped classrooms: students receive the primary instruction online, outside of scheduled times. Students will then need to complete the activity through online learning and will then apply what was learnt online. This would take place during the scheduled class times and deal with assignments and projects, with the assistance of the instructor.

- Individual rotation: students work through some or all activities with the assistance of ICTs. Typically, the student has the option of which approach would best suit their circumstances.
- Station rotation: students' progress through a circuit of activities at various learning stations during scheduled class times. One or more of the activities involve the use of ICTs. The instructor is present to provide guidance.
- Laboratory rotation: students receive instructions within face-to-face classes and then typically move to laboratories (e.g., ICT lab, Technology lab, Physics lab).

Enriched Virtual Model

Within this model, student's complete majority of their coursework face-to-face learning with the instructor and then complete the remaining activities remotely (Deivam & Devi, 2024). As noted by Kayalar (2021), the enriched virtual model differs from the flipped classroom model as it does not require students to attend face-to-face classes on designated days. These face-to-face classes serve two main purposes; namely, to enrich the learning experience with group work, and to hold students accountable through "check-ins" (Kayalar, 2021:25). The model also offers various benefits such as flexibility, off-campus learning experiences, and opportunities to explore emerging interests. In addition, the author notes that the model offers student- centred learning, the ability to personalise learning, development of self-management skills, and cost efficiencies.

b) Benefits and challenges of blended learning

Regardless of how it is implemented, blended learning approaches offer numerous benefits. Wahab, Othman and Warris (2016:115) state that the approach of blended learning "encourages the foundation of creating independent learners with reasonable critical thinking skills that are valuable for the current working environments". Preservice teachers can engage with ICT daily, as part of their activities in contemporary society,

through their cell phones/smartphones, tablets, or laptops, as a means of educating themselves.

- Wiebe et al. (2011:2), posit that a blended learning approach offers many benefits as it “provides flexibility in delivery and format that at times can be hard to match with comparable traditional methods”. Further studies indicate that blended learning methods, as opposed to purely face-to-face teaching and learning, and/or purely online modes of teaching and learning, have a higher impact on academic achievement than either online or face-to-face modes independently (Joksimović et al., 2015) and have “not only improved pedagogy, access and flexibility but also learner engagement and participation” (Ma’arop & Embi, 2016:41). Content presented online, offers students the opportunity to view material multiple times at any time, regardless of students’ physical location (Wiebe et al., 2011); it can also increase social interaction online and in-class, it can increase student self-directedness, it can increase student learning choices, it can be cost effective, and it can create responsive learning atmospheres (Clark, Kaw, & Besterfield-Sacre, 2016). This includes the ability to contact fellow students or teachers “through social networks and electronic mail, which enables them to discuss problems while studying” (Viljoen & Van Schoor, 2015:1). In addition, implementing effective blended learning approaches provides a wider range of access to teaching and learning material, “to overcome issues of distance between learners and instructors, and to facilitate increased peer interaction and collaboration” (McGuinness & Fulton, 2019:2).

Furthermore, as noted by Cavus and Ibrahim (2007:1), blended learning approaches have become increasingly appealing to those “who cannot attend universities on a full-time basis as a result of family or work commitments or financial difficulties”. Thus, the transformation of “placing the lecture out of class and the activities or the application of conceptual knowledge in class” (Saterbak, Voltz, & Wettergreen, 2016:2) can implemented, in which the highest cognitive load material is presented in the face-to-

face classroom. This is a result of the need for students to engage in in-depth, higher order cognitive thinking activities to understand and construct their own meaning of the topic.

Best and MacGregor (2017:204) however, argue that the challenge, specifically in practical subjects, such as Technology Education, is "to create collaborative environments that facilitate the sharing of new knowledge as well as finding a balance between conventional and virtual designing processes, strategies and solutions". These collaborative environments will be observed and discussed by the researcher, and the findings enriched with the surveys. The following four categories represent the challenges experienced when implementing blended learning methodologies, namely i) institutions, ii) instructors, iii) students, and iv) technological aspects (Ma'arop & Embi, 2016):

i) Institutions

One of the main institutional issues and challenges identified by Ma'arop and Embi (2016) is institutional culture. Students may be resistant to a blended learning approach, compared to traditional approaches, and teaching and learning instructors may find "it […] difficult to change the mindsets and practices of [those students who] are so used to the traditional method" (Ma'arop & Embi, 2016:48). Furthermore, it has been found that teaching and learning instructors had concerns about finding the right blend for their curriculum (Ma'arop & Embi, 2016) which impacts student progress and increases apprehension about implementing blended learning practices. The right mode of conveying information, taking into consideration the ICTs available, is crucial for the development of student knowledge. This claim is reiterated by Sam and Soong (2019:4), who report that teaching and learning instructors indicated that there is a "lack of support concerning logistics including technical support and management of the learning [of the] environment" and a "lack of interaction among instructors".

ii) Instructors

Ma'arop and Embi (2016:48) state that teaching and learning instructors lack technological and pedagogical skills and display a "lack of competency to create harmony between the two environments; face-to-face and online". Furthermore, instructors experience issues concerning the development of a "right blend, as in how much time

should be allocated for classroom meetings and virtual learning respectively" (Ma'arop & Embi, 2016:48). As the majority of the highest cognitive load is presented face-to-face, it is essential to establish the right blend. This is further echoed by Akbaşli and Akyüz (2021) who note that participants reported feeling inadequate due to a lack of general and special-field competencies. The authors elaborated that there is a need for intensive training to address the professional development needs of instructors (Akbaşli & Akyüz, 2021). This highlights the need for continuous and purposeful training, specifically in the practical-based courses, to ensure that instructors are abreast and prepared for changes within the contemporary society.

iii) Students

Students are often "unable to meet the demands of blended learning which require a high level of student discipline and responsiveness" (Ma'arop & Embi, 2016:48). Aspects, such as a lack of time-management skills and diverse backgrounds, influence student participation (Ma'arop & Embi, 2016). Wahab et al. (2016) report that students "feel that the information and learning experiences during blended learning are more likely to be confusing […] compared to the traditional classroom settings" (p. 116), and "that a traditional classroom setting will be better in creating social interaction, building social-emotional relations, support mutual team-working and improved learning process with other peers" (p. 119). Moreover, Wahab et al. (2016) report that students who obtain lower grades in a blended learning environment lack enthusiasm to learn or are reluctant to participate in a blended instructional approach because it falls outside of their comfort zone. This is supported by Akbaşli and Akyüz (2021) who note that low student motivation and interest make it difficult to have engaging experiences, and thus influences teaching.

iv) Technological aspects

Issues, such as defective internet connections, limited bandwidth or speed, and the "inability to view students' body language in [an] online environment" (Ma'arop & Embi, 2016:48) are amongst the biggest restrictions experienced when engaged in blended learning activities. Unfortunately, issues regarding unstable internet connections are often beyond the control of individuals. This study acknowledges that some students make use of internet cafes for teaching and learning purposes, which restricts students

from gaining immediate access to information. In addition, Akbaşli and Akyüz (2021) note that, for some educational technologies, such as computer aided design software (CAD), training is required. Thus, there is also a need to ensure that teachers and students are trained to use such software.

c) The use of ICTs

Uzunboylu, Bicen and Cavus (2011:720) explain that there have been three major developments in society regarding the use of ICTs. The first development is characterised by “the exponential growth of knowledge since the late twentieth century”; the second development is characterised by “the increasing popularity of digital culture”; and the third is characterised by the notion that “learners can learn anytime and anywhere in an online learning context”. The first development refers not only to the ability to understand information, but also to the ability to analyse and synthesise information. It is not enough to be able read or listen to content uploaded; instead, students must engage with content, and fully understand and apply their knowledge. The second development refers to the knowledge and skills of ICTs, and the ability to engage effectively with ICT. The third development refers to the availability of knowledge about the device being used, and the ability to locate information effectively. As society moves towards blended learning approaches, while considering these major developments, more and more research has focused on its application in HEIs.

In this study, learning material for presentation was [re]designed and implemented by the teacher educator, who was also responsible for uploading the information to Blackboard, the learning management system of the selected HEI. This content differs from face-to-face, lecture-based content, as online content should “lead students to discover, apply, and then explain important concepts to each other” (Saterbak, Oden, Muscarello, & Wettergreen, 2014:2). Fortunately, in the case of this study, the learning material had already been designed and developed by the teacher educator who presented the selected Technology Education course. In addition, the selected higher education institution responded to the nationwide call for learning to move online in 2020. This response included the distribution of learning materials, such as theory and content,

web links and additional resources through Blackboard. Online activities and submissions, tests and assignments had been implemented before the commencement of this study in the selected course. It was, however, encouraged that the teacher educator re-evaluate the theory and content made available previously. As Lim and Wang (2016:193) advise, activities for professional development need to be structured over time, instead of being presented all at once, and they need to provide “opportunities for follow-up practice and feedback”. It became increasingly necessary for the preservice teachers and the teacher educator in this study to have access to electronic devices and a stable internet connection, so that they could develop and engage in online activities and explore and keep up to date with new developments, described by the three major developments in society (Uzunboylu et al., 2011). Studies by Cavus and Ibrahim (2007), Clark et al. (2016), Saterbak et al. (2016), and McGuinness and Fulton (2019) confirm that students respond positively to the overall execution of blended learning practices, either at the initial implementation, or by expressing “a greater affinity for it over time relative to traditional modes of instruction” (Saterbak et al., 2016:4).

As stated by Hardman (2005:259), the following challenges are exacerbated by the use of innovative ICTs:

- *ICTs fail to account for the teacher's epistemic assumptions regarding the novel technology.*

  This challenge refers to the teachers’ understanding of the various technologies at their disposal, as well as knowledge of how these technologies can be used. The recent shift towards both online and blended learning approaches requires that educators rethink and research the ICTs and ICT software that is available.
- *ICTs lack a sufficiently nuanced understanding of the social, historical and contextual structures that inhere in an environment, and*

  This challenge is with reference to understanding the ICT’s availability to all the role-players involved, which include the ability to effectively use the ICTs. This further relates not only to the ICT’s availability to the teacher educator, but the ICT’s availability to the preservice teachers.

- *ICTs do not deal with the relationship between tools within the context of their use, leading to a failure to appreciate that using a novel tool is almost certainly contingent upon how other tools in the system are used.*

  This challenge emphasises the effective use of the ICTs, and not simply the role players' ability to use the ICT to complete a task. This challenge also has reference to questions about which ICT is most suitable, and most widely available to role players.

Furthermore, one of the key issues when implementing a blended learning approach is to ensure that learning does not become the sole responsibility of the student. Students responded negatively to increased personal responsibility for fostering their own learning (Saterbak et al*.,* 2016). Theory and content should be applicable and relevant to the anticipated learning outcomes and should be designed to achieve the outcomes. It is, therefore, imperative that material offered online contributes to the development of subject content knowledge in such a manner, that it does not burden students with information. The relocation of content-based lectures to online platforms ensures that class time can be utilised for "research based, active learning techniques […] that enhance student engagement and cognition"; these techniques include "question and answer periods, group problem solving, think-pair-share, cooperative learning, peer-to-peer learning, and small group discussion" (Saterbak et al*.,* 2016:2).

2.2.2 Blended learning in STEM education

STEM is a common acronym that refers to Science, Technology, Engineering, and Mathematics education. According to Sanders (2008), the National Science Foundation began using the term "SMET" in the 1990s but was later revised to STEM. The author (Sanders, 2008:23) notes four cognitive themes that align with STEM education; namely:

1. *Learning is a constructive, not a receptive, process.*
2. *Motivation and beliefs are integral to cognition.*
3. *Social interaction is fundamental to cognitive development.*
4. *Knowledge, strategies, and expertise are contextual.*

These themes emphasise constructive practices. The researcher also identifies a link with the interdependent elements of the theoretical framework, Community of Inquiry (CoI), as one of the frameworks that underpins the study. As stated, CoI is used to investigate online or blended learning practices. Joksimović et al. (2015) note that there is limited evidence on the blended learning approaches that impact academic achievement. Furthermore, Edannur and Marie (2017:32) state that “a critical component in meeting teachers’ technology needs is responding to teachers’ perception […] towards using the technologies in teaching”. Thus, understanding how preservice teachers perceive the use of technologies in classes will impact how blended learning approaches are implemented.

There are many studies conducted on the blended learning approach implemented in STEM-based courses. In a study conducted by Supriyadi, Desy, Suharyat, Santosa, and Sofianora (2023), the authors aimed to determine the effectiveness of a STEM-integrated blended learning model on students' science literacy. The results indicated that overall, the application of the learning model was effectively implemented and that it had a positive impact on students’ science literacy and their critical thinking skills. However, in a study conducted by Candido, Capilitan, Gillesania, Silva, and Reales (2023), the initial findings indicate that the blended learning model was not necessarily positively accepted in a physics senior high school class. The authors report on the findings indicate that students experience some or other difficulty with a change in the learning modality. The above-mentioned authors recommend that students find ways to cope with different difficulties and note that instructor planning and presentation are important when delivering the lesson. The need for digital support was highlighted as well.

In another study conducted by Attard and Holmes (2020), they reported on students’ perceptions of the blended learning approach explored in a STEM subject, specifically mathematics. The authors state that access to devices, the learning needs of students, and individual teacher perceptions were common reasons for the initiation of the implementation of the blended learning approach. Regarding access to devices, the authors comment on the use of learning management systems (LMS) as a source of teaching and learning materials, and as a means of communication between teachers

and students. Overall, the study indicates that students had positive attitudes towards the implementation of a blended learning approach in mathematics, although their perception was based on their access to ICTs and the variations in the way that it was used. For example, in one of the reported case studies, digital resources were available to students (such as a laptop or smartphone) but the integration of the device into the subject differed. Thus, the individual teachers in the study implemented the blended learning approaches differently. ICTs could be used to improve access to online resources, promote visualisations and the manipulation of concepts, or assist in enhancing understanding through applications. It also allowed teachers to refer to information and to improve on the teaching of the subject. Likewise, it offered students the opportunity to engage in self-paced learning.

However, limited research is available on the blended learning approach implemented in engineering education, and even less in Technology Education. A study by Saterbak et al. (2014:3) found that “no publicly available videos existed for teaching the engineering design process at any undergraduate level”. Nevertheless, the authors emphasise that the implementation of blended learning practices should focus on “process knowledge”, which is described as “how to do something”, and that such process knowledge is crucial in the “teaching of problem solving, design process, modelling, and research” (2014:4). In a study conducted by Bazelais and Doleck (2018), the authors examine the efficacy of the blended learning approach in a college mechanics course. A comparative case study was implemented, as the authors compare performance between face-to-face classes and blended learning classes. The findings indicate that the implementation of a blended learning approach positively impacted student learning outcomes and the quality of the instructional activities.

This is imperative for understanding the development of technological literacy through using blended learning approaches. In a study conducted by Platonova, Orekhovskaya, Dautove, Marynenko, Kryukova and Demir (2022), the authors examined 318 studies related to blended learning and higher education of which, 31 related to STEM education “covering physics, chemistry, mathematics, science, engineering, and environmental education” (2022:4). It should be noted that Technology Education does

not appear under the STEM education outlined in the study. Therefore, the researcher aims to contribute towards this gap.

2.2.3 Technology as a subject

The word “technology” stems from the Greek words techne (skill, art, craft) and logos (word, reasoning) (Tulley, 2008). In general terms, the word “technology” refers to “how people modify the natural world to suit their own purposes” (Heymans, 2007:44); it is the act of *doing and* solving problems. Given its foundational position in shaping human interaction with the world by doing and solving problems, technology naturally intersects with education. It has a direct link to education as it fosters learners to become functional and contributing members of society.

The subject Technology, along with art and economics, was introduced in the South African curriculum to “provide education relevant to the needs of learners and society as well as contributing to the person power requirements of the country” (Stevens, 2006:2). The introduction of Technology, which finds its basis in academic and vocational pathways, required a new way of thinking. Within the senior phase, Technology is aimed at the development and cultivation of the required technical engineering competencies (DBE, 2011). As noted by Heymans (2007:123), “South Africa has had no formal subject known as Technology in its schools until the introduction of Curriculum 2005 and Outcome-based Education (OBE)”. However, according to Ankiewicz (2020), the subject has its educational roots in woodwork, metalwork, and home economics, which were taught prior to 1998. Technology can be divided into two main areas of learning on which learners are assessed, namely the teaching of theory-rich content (pen-and-paper examinations and tests), and the application of practical knowledge (mini-practical assessments) (DBE, 2011). Furthermore, the application of practical knowledge can be subdivided into hands-on activities, and graphical communication activities. As noted by Heymans (2007:46), the subject “is an important element in the education of every student”, and “occurs in both school and out of school”. In the intermediate phase, Technology is combined with Natural Sciences (DBE, 2011); however, as learners progress into the further education and training (FET) phase, they can branch off into

various focus areas, which include “Civil Technology, Mechanical Technology, Electrical Technology and Engineering Graphics and Design” (DBE, 2011:8). Core focus areas develop learners into becoming technologically literate; these include opportunities to,

- *Develop and apply specific design skills to solve technological problems;*
- *Understand the concepts and knowledge used in Technology Education and use them responsibly and purposefully; and*
- *Appreciate the interaction between people’s values and attitudes, technology, society and the environment (DBE, 2011:8).*

Traditionally, the subject has been associated with the “physicality of the classroom-based settings” (Best & MacGregor, 2017:202), but we find ourselves in the midst of adapting educational practices, in order to keep up with an ever-changing world. Thus, the introduction of blended learning methodologies becomes ideal for supporting various learners and students, and for preparing them for a technology-centred world (Jarman, 2019). As stated by Clark et al. (2016:2), the teaching of technical subjects using traditional methods “is emerging as an ineffective and inferior method of instruction”; therefore, there is a need to shift towards integrating face-to-face teaching with online learning activities using ICTs.

Regarding the higher education course chosen for this study, the course Technology is offered over a period of four years in the undergraduate BEd degree. The course was chosen as it is a practical-based course in which blended learning was only recently offered. The Technology Education course is taught across the four undergraduate years and is divided into content (taught in the first and second years), and didactics (taught in the third and fourth years). Focus areas, such as the introduction to Technology Education; materials and processing; mechanical systems and control; graphic communication; electrical systems and control, and structures, are a few of the topics covered in the first two years of preservice teachers’ studies. Moreover, in the final two years, focus areas, such as Technology teaching, technological process teaching/learning, and concepts of Technology teaching are taught. It is, therefore, essential that on completion of their four-year degree, preservice teacher are well-rounded Technology educators who can:

use a combination of skills, knowledge and resources in a variety of contexts to teach technology as learning area in the senior phase within a real-life technological context. The [preservice teacher] will be able to demonstrate the ability to understand, use, manage, and assess technology as learning area and interpret the curriculum and plan relevant assessment and learning activities (University of the Free State, 2023:9).

2.2.4 The design process

The design process, also known as the technological process, is often referred to as the backbone of Technology. It can be described as a sophisticated and systematic thinking process that involves several steps; namely, investigating, designing, making, evaluating, and communicating (IDMEC) (Hynes, 2010; DBE, 2011). It should be used in designing and delivering technological learning aims (DBE, 2011). The initial implementation requires that a problem be introduced; thereafter, the user will apply their technological knowledge and skills to ensure that the problem is resolved. As noted in the Curriculum Assessment Policy Statement (CAPS) for technology, the key element to teach when focusing on the design process is the ability of the user to design (DBE, 2011). Figure 2.1 below provides a graphical representation of the design process, as adapted from the CAPS for technology (DBE, 2011) and illustrates the relationship between each step.

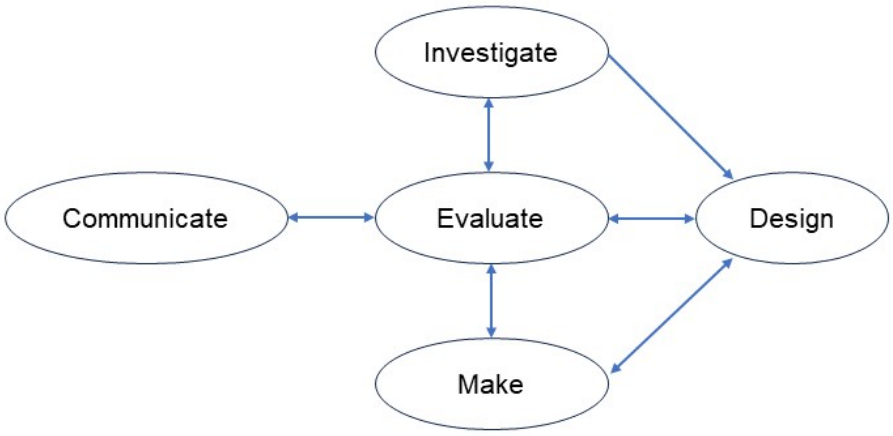

Figure 2.1: The design process in Technology Education (Adapted from DBE [South Africa, 2011:10])

The design process is not linear, but rather a cyclical process with a fixed sequence that is often rooted in evaluation (DBE, 2011). As the user engages with the problem at each step, evaluation will determine whether the user can progress to the next step. The practical tasks should therefore be structured according to the sequence of the steps (i.e., IDMEC). The practical task(s) may also focus on one or more aspects of the design process and not necessarily the entire process (DBE, 2011).

2.2.5 Technology in the context of teacher training programmes

Teacher training programmes are designed to equip current and aspiring teachers with the knowledge, skills, and pedagogical strategies needed to effectively teach and manage classrooms. These programmes, within STEM related areas, often include a blend of theoretical knowledge and practical skills, focusing on areas such as engineering, design processing, and digital literacy. The subject-specific courses offered have a direct link to the subjects offered at school level. Within the context of this study, this section will focus on teacher training programmes with a focus is on Technology Education.

Scholars in the field of Technology Education assert the need for teacher training programmes to develop strategies to enhance Technology teaching and learning processes to ensure the production of well-prepared Technology teachers (de Vries, 2000; Gumbo, 2016; Mapotse, 2017; Pappa, 2024; Seleke, Speight Vaughn, & de Beer,

2018, Teis and Els, 2021). Effective teaching and learning programmes have obvious overall benefits, such as informed decision making, critical thinking, problems solving, and increased creativity. Other benefits include better nurturing, better earnings, crisis management, and overall better and responsible citizenship (Suwarma & Kumano, 2019). Needless to say, the need for effective teacher training courses is essential for the development of such programmes. However, this is not always the case.

Mapotse (2017:687) highlighted the need for teacher training programmes to ensure that graduates “are well prepared to use new tools for learning”. This is further supported by Pappa et al. (2024) who outline the challenge of teacher training and professional development programmes that do not adequately, or effectively enhance the subject. This highlights the need for preservice teachers to engage in activities that replicate the importance of the subject and its context within the modern world. Furthermore, Mapotse (2017:686) also note that “[m]any [Technology Education] teachers lack Technology Pedagogic Content Knowledge (TPCK)”. The lack of confidence makes it difficult to teach the subject effectively, which has rippling effects on learners and their technological literacy development.

The every changing technological world and the rapid developments which change the way in which we respond to our environments necessitates that we prepare learners and preservice teachers to adapt. As noted by Luckay and Marthinisen (2023), educational institutions are transformed to keep up. However, the findings presented in Mapotse (2017) study notes that Technology Education classrooms were ill-equipped to offer the practical components for the subject. This highlights the need for intervention measures, such as blended learning approaches, which can increase teaching and learning collaborations and make face-to-face learning more meaningful as a result of online learning.

Pappa (2024:16) further states that “preservice teachers’ familiarity with Technology Education depends largely on their elective choices” as Technology Education is usually paired in a broader elective of Natural Sciences and Technology (as taught in the intermediate phase). As noted by Pappa et al. (2024), if a learner is not properly prepared for or exposed to Technology Education at a young age, it could

cultivate resistance to/lack of confidence in engaging in a technologically driven society. This highlights the need to ensure that teacher training programme prepare students to fully understand the context and rationale for Technology.

2.3 THEORETICAL FRAMEWORKS UNDERLYING THE STUDY

Two theoretical frameworks underpin this study: the Technology Acceptance Model (TAM) and the Community of Inquiry (CoI). These frameworks were selected to provide a comprehensive understanding of the factors influencing technology adoption and the dynamics of learning communities in blended learning environments. In the following sections, the researcher delves into the theoretical underpinnings of the TAM and CoI frameworks, interpreting their core components and relevance to this study. Thereafter, the practical applications of each framework is discussed, illustrating how they inform the design and implementation of blended learning environments in higher education. Finally, the section concludes by outlining the relationship between the two frameworks, as the first research question is addressed by TAM, while the second and third research questions are answered by CoI. The results from both frameworks, and thus the three research questions, collectively contribute to answering the main research question.

2.3.1 Technology Acceptance Model

The Technology Acceptance Model (TAM) is the first theoretical framework that underpinned this study as it relates to the first research question which asks, “How do preservice teachers perceive and understand blended learning within a university context?”. The TAM was introduced by Davis in 1989 as an extension of Ajzen’s theory of reason action (TRA) (Ghani, Hamzah, Ramli, Ab, Daud, Romli, & Mokhtar, 2019). The latter model explains that “any human behaviour is predicated and explained through three main cognitive components” (Taherdoost, 2018:961). These three components of the TRA model include attitudes, social norms, and intentions. However, Taherdoost (2018:961) states that due to the “uncertain theoretical and psychometric status in the TRA model” the TAM framework was designed. The updated TAM framework thus posits

that user motivation can be explained by three factors, namely (i) perceived usefulness, (ii) perceived ease of use, and (iii) attitude towards using (Granić & Marangunić, 2019, Taherdoost, 2018). These factors can determine whether users view ICTs as favourably or unfavourably. The TAM framework can further include external variables such as training requirements, user participation and inclusion in design and implementation, and system characteristics (Taherdoost, 2018). These external variables influence perceived usefulness and perceived ease of use in the following ways:

- **Training Requirements**: Adequate training can enhance users' confidence and competence in using the technology, thereby increasing perceived ease of use (Liu & Ma, 2023). When users feel well-trained, they are more likely to perceive the technology as useful because they can utilize its features effectively.
- **User Participation and Inclusion in Design and Implementation**: Involving users in the design and implementation process can lead to a better alignment of the technology with their needs and preferences, especially if the users are involved as early as possible (Bano & Zowghi, 2015). This involvement can increase perceived usefulness as the technology is tailored to their specific tasks and workflows. Additionally, it can improve perceived ease of use by ensuring that the system is intuitive and user-friendly.
- **System Characteristics**: The features and functionalities of the system, such as its reliability, speed, and user interface design, directly impact perceived ease of use. A well-designed system that performs reliably and efficiently will be perceived as easier to use (Ke, Sun, & Yang, 2012). Furthermore, if the system's characteristics align well with the users' inherent requirements, it will be perceived as more useful.

There are three factors that underpin the TAM framework that links external variables with the actual use. Furthermore, as noted by Zineldeen, Hongbo, Koffi, and Hassan (2020:5061), the framework clarifies the user “acceptance of innovation utilized in a diverse environment setting”. Thus, the TAM framework was found to be best suited for this study as it provides insight into preservice teachers’ intention to accept (or deny), adopt, and to use technology in blended learning spaces.

Three factors of the TAM framework

1. *Perceived usefulness*

Perceived usefulness refers to the user's belief that the system will increase or enhance job performance (Granić & Marangunić, 2019; Murillo, Novoa-Hernández, & Rodríguez, 2021). As noted by Venkatesh and Davis (2000), perceived usefulness is impacted by job relevance, results demonstrability, output quality, and image. Thus, if a preservice teacher perceives the ICT, or blended learning approach, as useful, they are more likely to adopt the ICTs in support of reaching the intended outcome or goal.

2. *Perceived use of ease*

Perceived ease of use refers to the user's belief that the system would be easy to use (Granić & Marangunić, 2019; Murillo et al., 2021). Zaineldeen et al. (2020) identify that perceived use of ease is impacted by two factors, namely anchors and adjustments. Anchors are seen as the general belief about the ICT and its usage; whereas adjustments are seen as the belief that is shaped by the experiences of using the ICTs. The authors (2020) elaborate that anchors are linked to computer self-efficacy, perception of external control, computer anxiety, and computer playfulness. The more a user engages with the ICTs, the more their beliefs are confirmed or discarded. The adjustments are linked to perceived enjoyment and object usability. These adjustments are usually context specific as it will be informed by a particular ICT. Positive experiences will therefore lead to a more optimistic approach to the ICT, whereas a negative experience discourage use.

3. *Attitude towards using*

Attitude towards using refers to the whether the user accepts or rejects the system (Granić & Marangunić, 2019; Murillo et al., 2021). If the user perceived the ICT as useless and difficult to use, the ICT is then less likely to be implemented. However, if the user perceived the ICT as useful and easy to use, it is more likely to be implemented. Thus, their attitude is shaped by their engagement in the first two factors (i.e., perceived usefulness and perceived use of ease).

2.3.2 Practical application of the TAM framework

Zaineldeen et al. (2020:5061) note that “TAM is enormously functional” in education. Exploring the acceptance or rejection of technology in education is crucial, especially with the rise of online and mobile learning. Figure 2.2 below provides a graphical representation of the TAM framework, illustrating the relationships between perceived usefulness, perceived ease of use, attitude towards using, and actual system use.

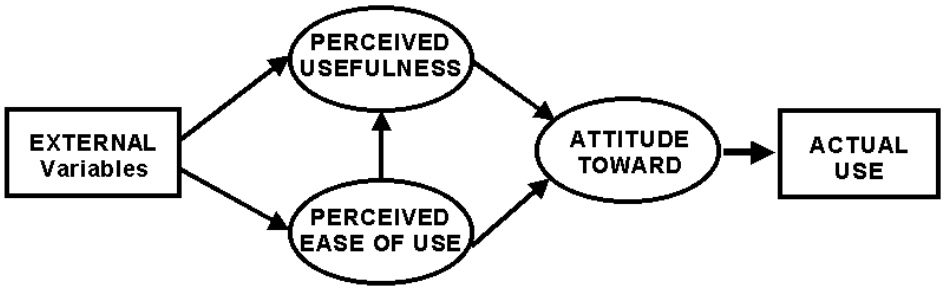

Figure 2.2: Technology Acceptance Model (Adapted from Fenech [1998:629])

As discussed in section 2.3.1, there are three factors that underpin the TAM framework: namely, the perceived usefulness, the perceived use of ease, and the attitude towards using. These factors are initially brought about by an external variable. In this study, the external variable is the abrupt change in the education system that was brought about by the COVID-19 pandemic. The pandemic significantly accelerated changes in education, prompting a rapid shift from face-to-face to online and blended learning modes. However, this transformation was also influenced by other variables, such as the Fourth Industrial Revolution (4IR), which introduced advanced technologies and digital tools into the educational landscape (Yuhasriati, Jasmaniah, Ma’awiyah, Zulkifli, Syabuddin, Hamid, Hamidansyah, Ridhwan, Hambali, Ilyas, & Bahri, 2020; Mostert, 2020). Additionally, changes in educational policies and increased pedagogical innovations also played crucial roles in this transition (see section 1.2). These combined factors have collectively driven the move towards more dynamic and adaptable educational models.

The relationship between the core constructs in Figure 2.1 is linear. More specifically, the model posits that perceived usefulness and perceived ease of use directly

influence users' attitudes towards using a technology, which in turn affects their behavioural intention to use the technology, ultimately leading to actual system use. To put it simply, if a preservice teacher perceives the ICT as useful and easy to use, the attitude towards using is positive and the ICT is more likely to be used. Conversely, if the preservice teacher perceives the ICT as useless or difficult to use, the attitude towards its implementation is less likely to occur. Furthermore, TAM has been widely used in educational settings to study the acceptance of various educational technologies. Its application within this study can provide valuable insights into how preservice teachers might engage with blended learning models.

In summary, the TAM framework effectively explains how preservice teachers' attitudes towards ICTs influence their acceptance and use of blended learning approaches in Technology Education. In addition, the TAM encouraged the researcher to think of the characteristics of the blended learning environment and can help identify factors that influence preservice teachers' willingness to adopt and integrate blended learning practices within the course, and within their teaching and learning activities.

2.3.3 Community of Inquiry

The Community of Inquiry (CoI) framework underpins this study as it relates to the second and third research questions which asks ""How are preservice teachers engaged in blended learning Technology Education courses in South Africa?", and "What are preservice teachers' perceived impacts of blended learning in Technology Education courses?" respectively. The initial CoI framework, rooted in Dewey's 1938 work, emphasizes that students take responsibility for constructing and confirming meaning through collaboration (Swan, Garrison, & Richardson, 2009). Garrison, Anderson, and Archer (2000) then expanded Dewey's work to include three interdependent elements: teaching, cognitive, and social presence (Mudau & Van den Berg, 2023). They further emphasized critical thinking, knowledge construction, collaboration, and community formation (Garrison & Archer, 2000; Ketsman, 2022).

As noted by van der Merwe, Bozalek, Ivala, Nagel, Peté, and Vanker (2015:12), the CoI framework is “widely used in the design of online and blended courses, evaluating student satisfaction and researching online teaching and learning”. Thus, the researcher found this framework best suited to answer these research questions. Furthermore, the CoI framework provides a holistic overview for understanding how three different elements interact and influence the learning experience for students. As noted in a retrospective paper published by Garrison, Anderson, and Archer (2010), course design was a significant factor in the underachievement of high critical thinking skills among students. Effective course design is crucial in addressing the second and third research questions because it directly influences engagement and perceived learning outcomes. Well-designed courses incorporate interactive elements, integrate technology effectively, and provide clear structure and support, all of which are essential for fostering an engaging learning environment. Thus, as reported by Pool, Reitsma and van den Berg (2017:155), the CoI framework “is a valid and trustworthy instrument to measure the quality of online [and blended] learning environments”, which can assist lecturers in creating, implementing, and assessing the effectiveness of blended learning environments. The three interdependent elements - teaching presence, cognitive presence, and social presence - are discussed in detail in the following section.

Interdependent elements of the CoI framework

1. Teaching presence

The teaching presence can be seen as “the design, facilitation, and direction of cognitive and social processes” (van der Merwe et al., 2015:12) and is said to provide leadership throughout the course (Akyol & Garrison, 2011). Moreso, it refers to the design of the course, facilitation, and direct instruction in the teaching and learning activities, aimed towards cognitive and social processes (Mudau & Van den Berg, 2023; Siah, Lim, Lau & Tam, 2020). The teaching presence is a critical element, as it focuses on the instructor’s roles and impact. Although it is generally regarded as the teaching and learning activities, the teaching presence can also refer to the other aspects of the instructor role, such as posting announcements, designing assessment activities, providing feedback, and other related activities. Thus, the teaching presence refers to

“the course design, curriculum outline, and teaching methods and is related to students’ evaluation of the quality of their educational experience” (Mudau & Van den Berg, 2023:4).

2. Cognitive presence

The cognitive presence can be defined as “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical Community of Inquiry” (Garrison et al., 2001:11). This presence is concerned with the process of creating meaningful learning experiences that encourage the acquisition of the intended learning outcomes through reflection. As noted by Akyol and Garrison (2001), there are often questions regarding whether higher-order thinking skills can be achieved in a blended learning approach. As suggested by these authors, greater focus should be placed on connecting the outcomes to the processes to support the cognitive presence in blended learning approaches. To achieve this, Garrison et al. (2001), suggested a practical inquiry model. The model consists of four phases, namely: triggering event; exploration; integration, and resolution. These four phases can be used to cultivate the cognitive presence within the course. However, as stated by Castellanos-Reyes (2020), those engaged in online learning need the social presence as well, as it encourages collaboration.

3. Social presence

The social presence refers to the development of an individual within the community. It requires the individual to be able to “project themselves socially and emotionally as real people within a CoI” (Mudau & Van den Berg, 2023:4) and to “communicate purposefully to enhance collaborations and group cohesion during lesson activities” (Siah et al., 2020). This requires that preservice teachers engage with peers and their lecturer(s), as such engagements can enhance their learning experience and assist in the development of positive learning relationships. Further suggested by Mudau and Van den Berg (2023), the social presence impacts the cognitive presence; therefore, a positive connection between the social and cognitive presence will result in a positive blended learning experience.

2.3.4 Practical application of the CoI framework

As noted by Castellanos-Reyes (2020:559), “it is time for us to move from making sense of what an efficient online experience is to designing such an experience”. The theoretical relationship between the teaching, cognitive, and social presence is represented by a CoI framework model as depicted in Figure 2.3.

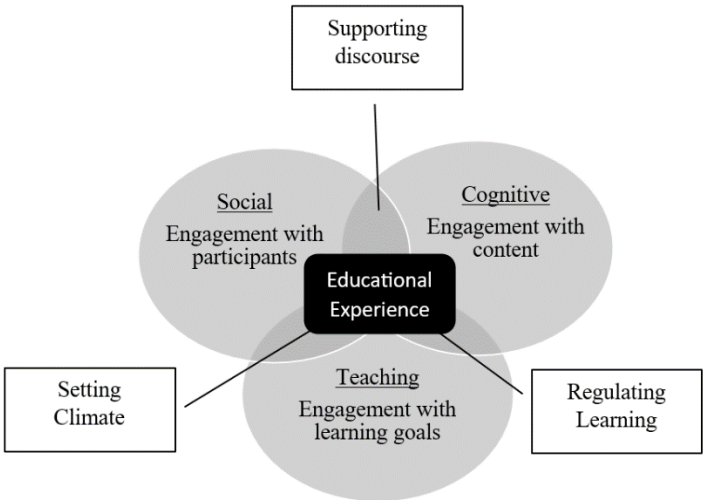

Figure 2.3: Elements of an Educational Experience (Adapted from Garrison et al. [2000:87])

The positive relationship between these elements aims to create a quality educational experience. The model highlights the influence and link between each presence on supporting discourse, setting climate, and regulating learning towards the overall educational experience.

With reference to supporting discourse, Erdogan (2016) notes that supporting discourse is crucial for creating a constructive and collaborative learning environment. Peacock and Cowan (2016) simplify this influence by referring to *meaning-making*, which is created through the interaction of social and cognitive presences. This emphasizes the need to create meaning in social engagements, focusing on the engagement in shared discussion, goal setting, strategy review, and consideration of potential barriers.

Setting climate is created between the social and teaching presences. Peacock and Cowan (2016:273) note the importance of “any CoI to set the tone of openness, fairness, safety, and debate, and above all to nurture self-efficacy”. This highlights the importance of forming meaningful professional relationships with students to encourage

interaction and build trust. Yamo, Kim and Dreamson (2022) further emphasise the need to encourage and maintain individuality and encourage students to project their personality within the learning space.

Regulating learning is created through the interaction of the teaching and the cognitive presences. This interaction addresses how students are expected to interact with the tasks and activities within the course. As noted by Peacock and Cowan (2016), the term is better understood by the concept of deepening understandings, as it focuses on the subject and the development of abilities that facilitate learning.

Within this study, the teaching presence refers to the pedagogies employed to teach preservice teachers in a blended learning class. This includes the blended learning practices employed to enhance technological literacy, the assessment activities, the ICTs used, and any other action carried out to achieve course outcomes. The cognitive presence can be seen as any blended learning activity that encourages higher cognitive order thinking skills to be applied, such as participating in the portfolios. Finally, the social presence refers to the community is created from the interaction between participants, as well as the interactions with the instructor. Interactions must be positive and enriching to ensure the effectiveness of social presence.

Therefore, the CoI framework offers ways in which learning could, and should take place. It requires collaborative, engaging, and adaptable learning activities to be created to ensure that a community of inquiry is created. Furthermore, the framework can be used to identify and map out learning activities through setting discourse, setting the climate, and regulating learning.

2.3.5 The relationship between the theoretical frameworks

The Technology Acceptance Model (TAM) and the Community of Inquiry (CoI) frameworks were chosen for this study due to their relevance in understanding the perception, interaction, and engagement between users and information and communication technologies (ICT). The TAM framework was selected for its robust ability to measure technology acceptance, which is crucial in understanding preservice teachers'

initial perceptions of blended learning. The CoI framework, on the other hand, offers a comprehensive lens to examine the social, cognitive, and teaching presence in blended learning environments, making it ideal for exploring engagement and perceived impact. Both frameworks emphasize a user-centred approach to learning. In this study, the TAM outlines preservice teachers' acceptance of a blended learning in a Technology Education course, while the CoI framework assesses the quality of the implementation of the blended learning approach in a Technology Education course.

The first research question aligns with TAM as it focuses on preservice teachers' perceptions and acceptance of blended learning technologies. Specifically, TAM was used to address the research question: "How do preservice teachers perceive and understand blended learning within a university context?". The second and third questions align with CoI, examining engagement and perceived impacts within the learning community. Thus, the CoI framework was used to respond to "How are preservice teachers engaged in blended learning Technology Education courses in South Africa?", and "What are preservice teachers' perceived impacts of blended learning in Technology Education courses?" respectively. Integrating the TAM and CoI frameworks allowed the researcher to comprehensively analyse the blended learning approach implemented in Technology Education. Moreso, the TAM addressed the individual acceptance of technology, CoI provides insights into the collective learning experience, ensuring a balanced evaluation of the blended learning environment.

TAM has been extensively applied to understand the factors influencing the acceptance and use of ICTs by both students and the educators/lecturers. As noted by Granić (2023), TAM is widely and prominently used in educational contexts; more so, TAM is used to evaluate the acceptance of blended learning. The author further elaborates that "[e]ducational settings involve a wide range of potential uses of ICT products and services used to support the process of knowledge transfer and acquisition" (Granić, 2023:189). Various studies have also reported on the use of TAM to assess preservice teachers' engagement with ICTs. For example, studies have shown that TAM can be used to effectively capture factors influencing user acceptance of the ICTs (Al-Rahmi, Yahaya, Aldraiweesh, Alamri, Aljarboa, Alturki, & Aljeraiwi, 2019; Pinho, Franco,

& Mendes, 2021), it can effectively predicts preservice teachers' willingness to use ICTs (Gül and Ateş, 2022; Teo, 2008), and it can respond to preservice teachers intention to integrate ICTs in their classrooms (Purnomo, Imron, Wiyono, Sobri, & Dami, 2023; Sulistiani, Setyosari, Sa'dijah, & Praherdhiono, 2023).

Furthermore, the CoI framework is designed to create and sustain meaningful learning experiences in online and blended learning environments. It has been used to examine how the teaching, cognitive, and social presence could predict course outcomes, and to recognize how specific course characteristics could affect the development of each of these presences (Peddell, 2024; Stenbom, 2018). Agiasotelis, Karteroliotis, Giossos, and Dania (2024:828) highlight that CoI "support the design and implementation of the teacher's professional development" programmes" and encourages collaborative learning. The CoI framework is also used in guiding instructional design and implementation (Fiock, 2020; Richardson, Arbaugh, Cleveland-Innes, Ice, Swan, & Garrison, 2012), assessing learning environments (Martin, Wu, Wan, & Xie, 2022), and supporting professional development (Saglam & Dikilitas, 2020). These diverse applications underscore the versatility and effectiveness of the CoI framework in enhancing educational practices and outcomes across various contexts.

In conclusion, TAM provides insights into preservice teachers' acceptance and perceived usefulness of the technology, while CoI offers a deeper understanding of their engagement and interaction within the learning community. Together, these frameworks enable a holistic evaluation of both the technological and pedagogical aspects of the blended learning experience, ensuring that the study addresses both acceptance and quality. This dual approach ensures that the research questions are not treated independently but are interwoven to provide a complete picture of the blended learning environment. Ultimately, this integration of TAM and CoI frameworks comprehensively answers the main research question: "How do South African preservice teachers experience blended learning in a Technology Education class?".

2.4 CONCLUSION

This chapter presented the literature review that explored blended learning and the use of ICTs, and blended learning in STEM education. This highlights the challenges and opportunities associated with integrating blended learning into STEM education, which requires hands-on and interactive learning experiences. The chapter then narrows down to Technology as a subject, the design process, and Technology in the context of teacher education. This contextualize the study by providing insight into what the subject is, and how it is taught at a national and international level.

Thereafter, the chapter presented the Technology Acceptance Model (TAM) and Community of Inquiry (CoI) frameworks, as the theoretical frameworks that underlies this study. The researcher introduced the frameworks, discussed each framework, and further discussed the practical application of the frameworks. By introducing and discussing these theoretical frameworks, the researcher lays a solid foundation for understanding how preservice teachers experiences of blended learning in Technology Education can be implemented and understood. The chapter further provides the reader with an overview of how the TAM and CoI frameworks are practically applied within the study.

The next chapter provides details on the research design implemented in this study. It explains how a multiple-case study design was used to investigate the perceptions, understanding, engagement, and experiences of preservice teachers and their instructor. The chapter also explains the data collection process carried out in this study.

SECTION A: CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The preceding chapters serve as a comprehensive foundation for this study. In Chapter 1, an introduction to the research, including the background, problem statement, research questions and objectives, significance of the study, and delimitations are provided. Chapter 2 offered a detailed literature review and discussed the theoretical frameworks of the Technology Acceptance Model (TAM) and the Community of Inquiry (CoI). Building on this foundation, this chapter discusses the research design and methodology used to explore preservice teachers' experience of blended learning in Technology Education. The chapter begins by restating the purpose of the study and the research questions. The research design, paradigm, and research approach are outlined. More specifically, a multi-case study design, pragmatic paradigm, and mixed methods approach. Thereafter, a description of the data collection process, and data analysis and interpretation are provided. This is followed by a discussion on the trustworthiness of the study and the ethical considerations. The chapter then concludes with a summary.

3.2 PURPOSE OF THE STUDY

The purpose of the study was to explore preservice teachers' experience of blended learning in a Technology Education course at a South African higher education institution (HEI). The study sought to determine the how a blended learning approach could be implemented in a third year Technology Education course. This was achieved by exploring preservice teachers’ perceptions, understanding, engagement, and experiences in a blended learning approach. As a result, the study sought to determine the feasibility of implementing a blended learning approach in the practical-based teaching training programme. It is anticipated that the findings will help preservice teachers and higher education institutions (HEIs) with the implementation of blended learning approaches in Sciences, Technology, Engineering, and Mathematics (STEM) subjects and courses.

3.3 RESEARCH QUESTIONS

The primary research question of the study asked how South African preservice teachers experience blended learning in a Technology Education class. This research question sought to generate data on preservice teachers' experiences of a blended learning approach.

The following served as secondary research questions used to unpack the primary research question:

1. How do Technology Education preservice teachers perceive and understand blended learning within a university context?
2. How are preservice teachers engaged in blended learning Technology Education courses in South Africa?
3. What are preservice teachers' perceived impacts of blended learning in Technology Education courses?

3.4 RESEARCH DESIGN AND PARADIGM

The strategy used to answer the research questions can be described as the research design. Within this study, a case study design was found best aligned with the research aim. As noted by Gall, Borg, and Gall (1996:545), case studies can be defined as "the in-depth study of instances of a phenomenon in its natural context and from the perspective of the participants involved in the phenomenon". Scholz and Tietje (2002:5) explain that case studies "should use multiple sources of information", regardless of the case design type. This study is underpinned by a multiple-case study design, with the intention of providing extensive insight into how a Technology Education course offers blended learning to facilitate learning for preservice teachers.

Accordingly, as stated by Yin (2003:47) "[e]very case should serve a specific purpose within the overall scope of inquiry". As such, this research design consisted of two cases whereby the first case study focused on a group of third-year Technology Education preservice teachers from 2022, addressing the second and third research questions. The second case study examined a group of third-year Technology Education

preservice teachers from 2023, addressing the first research question. This is outlined below for clarity.

- **Case Study 1**: This 2022 preservice teacher group was selected for their practical engagement and experience in a blended learning approach. Data were collected using document analysis, and the Community of Inquiry (CoI) survey to evaluate the effectiveness of the approach implemented in Technology Education.
- **Case Study 2**: This 2023 preservice teacher group was selected for their contribution towards the theoretical understanding of blended learning. Their perceptions and understanding were found relevant as they have not yet engaged in a blended learning approach implemented in Technology Education. Data were collected through an open-ended interview questions to gather insights into their perceptions and understanding of the approach.

The integration of findings from both case studies allowed for a comprehensive analysis of preservice teachers' perceptions, understanding, engagement, and experiences with blended learning in Technology Education. By comparing the theoretical insights from Case Study 2 with the practical insights from Case Study 1, the researcher was able to develop a holistic view of the blended learning approach's effectiveness and its impact on preservice teachers. Thus, enabling the researcher to respond to the main research question. Furthermore, as noted by Gustafsson (2017), multiple case studies allow for comparison between cases, providing a richer and more nuanced understanding of the phenomenon. This approach aligns with the intent of this study, which is to understand how preservice teachers experience a blended learning approach implemented in a practical-based course such as Technology Education.

In addition, a pragmatic paradigm was implemented which aligns with the views of Badley (2003:296) whereby “pragmatists see inquiry not as discovering what is really out there but as offering more or less useful descriptions to meet our particular needs and purposes”. This also aligns with the theoretical frameworks underpinning this study, as it provides insight into the experiences of preservice teachers engaged in blended learning activities. Likewise, as noted by Shaw, Conelly and Zecevic (2010:513), the pragmatic paradigm “is seen […] to achieve results that are meaningful and applicable to certain

populations". The application of a pragmatic paradigm in this research further aligns with that of Garrison and Neiman (2003:22), where "minds and selves emerge socially in critical and creative dialogue with the rest of the community". Thus, a pragmatic paradigm was found to be best suited, as it emphasises the practical application of knowledge and skills. It further emphasises the importance of the context in understanding how blended learning can be implemented in a practical-based course such as Technology Education.

3.5 RESEARCH APPROACH

The study employed a mixed-method research approach to gain rich and informative data. For the mixed-method approach, the study employed both qualitative and quantitative data collection tools. Qualitative research approaches are "used to answer questions about experience, meaning, and perspective, most often from the standpoint of the participant" (Hammarberg, Kirkman & De Lacey, 2015:499). Quantitative research approaches, on the other hand, focus on "gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon" (Babbie, 2010:45). Regardless of the differences between the two data collection tools, one can complement the other, and thereby provide a more holistic view of research, which is supported by narrative and numerical data. As stated by Shorten and Smith (2017), using a mixed-method approach has the following advantages:

i. Employing a mixed-method approach allows for appropriate answering of research questions that neither qualitative nor quantitative research methods would effectively answer alone.
ii. A better understanding can be achieved by employing mixed-method approaches, as any comparisons and variances in the collected data can be compared.
iii. Mixed-method would provide opportunities for preservice teachers to engage and report on their experiences and their practices across the research process.
iv. Mixed-method allows for the facilitation of different means to explore and enrich data collection. Furthermore, qualitative research allows for the

research questions to be explored in depth through document analysis and the open interview questions. The quantitative data collected from the survey offers a range of quantifiable responses.

As noted by Ivankova, Creswell and Stick (2006), there are several types of mixed-method designs which include variations of concurrent and sequential designs. However, in this study, sequential exploratory design was used. Sequential exploratory design involves two consecutive phases (Creswell & Plano-Clark, 2018). The first phase involved the collection and analysis of qualitative data. Thereafter, in the second phase, quantitative data was collected, then analysed in relation to that of the first, qualitative phase. Additionally, the researcher(s) can employ another round of qualitative data to further explore or explain the findings.

Both qualitative and quantitative data collection tools were used in this study, to strengthen the findings. This included qualitative data firstly collected through document analysis. The aim of this was to understand preservice teachers' engagement in the design process in a blended learning mode. The second qualitative data collected were through open-ended interview questions whereby the researcher aimed to reveal preservice teachers' perceptions and understanding of blended learning approaches in Technology Education in this data collection approach. According to Rahman and Areni (2016), qualitative data provide detailed descriptions of participants' perceptions, understandings, and experiences. The above author further notes that qualitative data are participant centred. Therefore, the data collected can help the researcher gain an in-depth understanding from the perspective of the participant. This approach was found to be best suited to the study, as it allowed participants to share their thoughts and opinions freely and openly. Moreover, it further provided rich insight into their perceptions and understanding of what a blended learning approach entails and how it can be implemented in a practical-based course, such as Technology Education. Furthermore, it also provided an understanding of how the preservice teachers engaged in a blended learning approach in the design process. Figure 3.1 provides a graphical representation of the mixed-methods approach applied in this study. It outlines the qualitative and

quantitative data collection tools, the year that the data were collected, and the number of preservice teachers who participated in each tool.

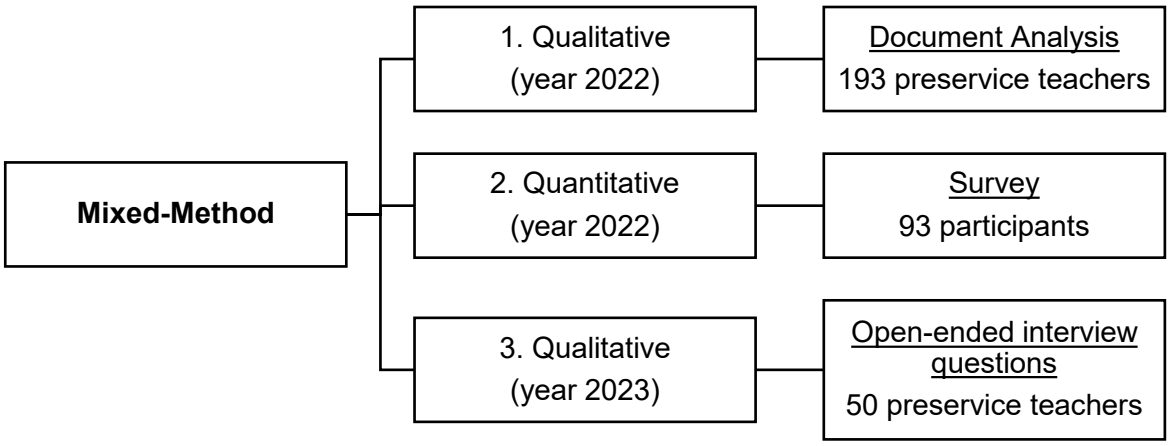

Figure 1.1: Mixed-method Approach Applied

More specifically, Table 3.1 below details the sequential, exploratory design implemented in this study to provide a deeper understanding of the data collected with reference to the secondary research questions.

Table 3.1: Sequential Exploratory Design

Year	Phase	Sequential Exploratory Design	Secondary Research Questions
2022	Phase 1	Part 1	
		Qualitative data collected through document analysis regarding preservice teachers' engagement in a blended learning approach, implemented in a Technology Education course.	Research question 2: How are preservice teachers engaged in blended learning Technology Education courses in South Africa?
		Part 2	

		Quantitative data were collected through a Likert-scale survey to understand the experiences of preservice teachers in blended learning in a Technology Education course.	Research question 3: What are preservice teachers' perceived impacts of blended learning in Technology Education courses?
2023	Phase 2	Part 3	
		Qualitative data were collected from the open-ended interview questions regarding preservice teachers' perception and understanding of blended learning in a Technology Education course at a HEI.	Research question 1: How do Technology Education preservice teachers perceive and understand blended learning within a university context?

Finally, the results from this sequential explanatory design were analysed and compared to answer the main research question, which asks "How do South African preservice teachers experience blended learning in a Technology Education class?". These findings are elaborated on in Section C: Chapter 4.

3.6 DATA COLLECTION AND ANALYSIS

This section of Chapter 3 highlights the data collection and analysis processes. Below, the researcher discusses the research site, target population, data collection tools, and the data collection and analysis processes.

3.6.1 Research site

One HEI in the Motheo district of the Free State province was selected; of which preservice teachers in one Technology Education course were selected for this study.

DePoy and Gitlin (2016:173) state that the researcher “must examine the nature of the phenomenon that is of interest as the basis for deciding how to proceed”.

This chosen higher education institution was established in 1904, and in 2023 hosted an estimated 39 338 students across seven faculties, of which 32 934 students were registered for undergraduate degrees on the main campus (UFS, 2023). This higher education institution is a historically white university. The two case studies within the multiple-case study design were narrowed down to the Technology discipline within the Faculty of Education, where the Technology laboratories are equipped with all the necessary tools and equipment to complete practical tasks prescribed by selected courses.

The course selected for this study is the third-year Technology Education course at the HEI; it can be presented asynchronously, as well as synchronously, in designated classrooms and technology laboratories. The teaching and learning activities were extended to designated classrooms on the HEI campuses. In 2020, the course was taught primarily online, and the HEI offered resources for students to engage online. The HEI also offers students the opportunity to use the computer laboratories available to them and provides access to uncapped Wi-Fi. Students are also given free data via an application, with restricted use for academic purposes, giving students access to the University’s LMS and other educational learning sites. As the world returned to a new norm, the HEI returned to face-to-face teaching in 2022. Thus, recognising the potential of online learning, the Technology Education course was presented in a blended learning approach.

3.6.2 Target population

To answer the research question identified in Section 1.4, the researcher needed to identify participants who would be able to contribute meaningfully to the study. These participants are referred to as the target population. A target population can be described as “a group or set of elements that you want to know more information about” (Glen, 2020: Online). This study purposefully selected preservice teachers engaged in a Technology Education course at a third-year level. The third-year group was chosen because the

preservice teachers were exposed to the initial blended learning approach implemented at the HEI. However, the 2022 group engaged in a blended learning approach in the first semester, whereas the 2023 group did not. It should be noted that the blended learning approach implemented in 2022 was predetermined by the lecturer, as a result of the COVID-19 pandemic and the resumption of the face-to-face activities. However, the 2023 group at the time, did not engage in any blended learning approach in the Technology Education courses offered at the HEI; thus, the input is not based on previous engagements. Furthermore, both groups of third-year preservice teachers provided detailed feedback regarding the effectiveness and potential of blended learning. These participants had valuable experience in blended learning teaching and learning environments.

3.6.3 Sampling methods

The study employed a purposeful sampling approach, which is a non-probability sampling method whereby the researcher selects participants based on selected criteria (see section 3.6.2). The participants considered and selected for this study was two groups of third-year Technology Education preservice teachers. In 2022, 193 preservice teachers participated in the qualitative data collection approach, representing the entire class. These participants all submitted individual and group portfolios. However, for the quantitative data collection approach, only 93 of the 193 participated in the Community of Inquiry (CoI) survey. This discrepancy highlighted a challenge in maintaining participation within this year group. As noted in section 3.6.4, no marks were awarded for the submission of the individual and group portfolio as part of formative feedback. In addition, participation in the CoI survey was voluntary.

In 2023, only 50 participants from a group of 180 Technology Education preservice teachers displayed willingness to engage in the open-ended research questions. This lower participation rate also reflects the voluntary nature of the study.

All participants were informed about the purpose of the study and assured that their participation was voluntary. They were free to withdraw at any time without facing

any repercussions or penalties. This voluntary participation is evident in the fluctuation of participant numbers across different data collection methods.

3.6.4 The role of the researcher

As stated by Holmes (2020), the researcher's world view can influence their ontological assumptions, epistemological assumptions, and assumptions of human nature. In addition, the author notes that these assumptions further influence "how research is conducted, its outcomes, and results" (2020:2). Thus, it is necessary to acknowledge the role of the researcher in this study. Holmes (2020) avers that the positionality of the researcher is identified in three areas; namely, (i) the subject under investigation; (ii) the research participants; and (iii) the research context and process. As Scholz and Tietje (2002:4) explain, a researcher may choose to do a specific study because they are "intrinsically motivated to investigate a certain case", and "takes responsibility and is accountable for the analysis and its consequences". Thus, the present study emanates from the researcher's position as a teacher educator for the third-year preservice teachers in the Technology Education course, within the same HEI where the study was conducted. As part of the researcher's responsibilities, they were responsible for the teaching and learning activities of the research participants; that is, the third-year preservice teachers during the second semester of 2022 and 2023.

Throughout the process, the researcher was personally responsible for the data collection processes from the facilitation and collection of document analysis to the qualitative survey, and the open interview questions. To the best of their knowledge, they remained neutral in terms of their views of blended learning in a practical-based course. However, the researcher did not attempt to hide the intent of uncovering their engagement in a blended learning approach. To elaborate, throughout their engagement in the project portfolio, they were careful not to dictate how they should engage online or face-to-face but rather, encouraged them to document their engagement. The survey was adjusted from the existing and validated CoI framework which outlines how respondents experienced the online and blended learning environments. The open interview questions were distributed at the beginning of the semester to understand preservice teachers'

perceptions and understanding of blended learning in Technology Education, specifically as they had already engaged in blended learning approaches in at least one other course. Thus, participants already had a brief introduction to the blended learning approach implemented in HEIs. Their responses further outlined how the blended learning approach would be implemented.

In all aspects of the data collection, no marks were awarded for their engagement in the study. With reference to the portfolio submission and assessment, their engagement in the design process is a necessary aspect of Technology Education as a practical-based course, and thus formed part of the formative assessment. Preservice teachers were made aware that only their final project and presentation contributed to summative assessment.

3.6.5 The relationship between the researcher and the participants

A relationship with participants may result in “participant bias” or “subject bias”. This term can be described as the process encountered when a participant will “sometimes second-guess what the researcher is after, or change their answers or behaviours in different ways, depending on the experiment or environment” (Farnsworth, 2019: Online). A prior relationship had existed between the researcher and the 2022 preservice teachers involved in this study, as the researcher was the teacher educator in the first semester. This relationship could have compelled respondents to participate in the study; however, this was negated by informing participants that their engagement was completely voluntary. Their participation in the portfolios was necessary as part of the course intent was to develop technological literacy. Similarly, the 2023 preservice teachers were informed that their participation in the open interview questions was completely voluntary. However, unlike the 2022 cohort, the 2023 preservice teachers and the researcher did not have a prior relationship.

3.6.6 Data collection tools

a) Qualitative Data Collection Tools

Document analysis (See Appendix F and G)

Document analysis was used to report on the 2022 group of preservice teachers' engagement in two Technology portfolios. This was found to be the most suitable as preservice teachers would have to submit portfolios to outline their engagement in the design process, but also, because document analysis allowed flexibility (Kutsyuruba, 2023). Kutsyuruba (2023) notes that document analysis can be analysed with other quantitative and qualitative methods as a means of data triangulation and increased credibility. It also provides researchers with a means of gathering data on events that are no longer observable.

In this study, both portfolios outlined the design process, used to complete practical activities in Technology Education. The first portfolio was an individual submission that focused on the investigation and design. This portfolio was submitted through Blackboard Learn and required preservice teachers to investigate a possible scenario wherewith they would then design the solution to the scenario. More specifically, the portfolio required the preservice teacher to indicate the problem they wanted to resolve. This required the preservice teacher to investigate a scenario and outline if additional research was necessary (and to elaborate on what research was necessary). This helped the researcher identify if they content presented was adequate and applicable or not. Furthermore, the preservice teacher would need to identify what sources they consulted in the investigative and design steps. The preservice teacher would need to indicate what additional learning platforms or knowledgeable other was consulted/approached. This gave the researcher a sense of whether the preservice teacher conducted online or face-to-face research in an attempt to understand the blended learning approach.

The second portfolio was a group submission that focused on investigating, designing, making, evaluating, and communicating. It should be noted that the investigating and designing of the group submission was based on the individual portfolio submission, wherein preservice teachers were expected to engage and decide on the

most applicable scenario and design. The group portfolio required additional information to help the researcher understand how the blended approach could be implemented. To elaborate, the investigative section indicated how preservice teachers group themselves (on Blackboard sign up or in class), the design section required them to identify if additional sources were consulted and if additional research was necessary, the making section required them to outline where they found it most comfortable and applicable to complete the project, and the communication section outlined how they communicated and which platforms were used. Furthermore, the group portfolio was submitted through Google Forms, as it allowed the researcher ease of access to the information. Both portfolios were submitted once their projects were completed before presentation.

Open-ended interview questions (See Appendix E)

Open-ended interview questions were distributed to the 2023 groups of preservice teachers at the beginning of the second semester. The interview questions elicited preservice teachers' perceptions and understanding of blended learning in Technology Education, more specifically, their familiarity with the blended learning approach; their understanding of the approach; the benefits and challenges with its implementation; how they proposed that the approach be implemented; their preferences and engagement, and their anticipated excitement about the possibility of its implementation. The interview questions provided insight that could support or contradict the approach implemented in 2022, with the responses further providing information on how the blended learning approach could be improved.

As noted by Chaudhary and Israel (2016), open-ended interview questions allow respondents to provide rich and detailed information. Riiskjær, Ammentorp and Kofoed (2012) note that open-ended questions offer the respondents an opportunity to explain their responses by asking follow-up questions. In addition, the above authors note that by doing so, the respondents may offer critical comments that are beneficial to the research study. These comments, however, lack interactive activity and would therefore not be ideal for personal or group interviews. Desai and Reimers (2019) posit that open-ended question responses are constructed and avoid biases; open-ended questions allow respondents to provide detailed responses, and they allow for a wider range of possible

answers. Thus, the open-ended interview questions were found most suitable for qualitative data, as respondents could answer in their own words and understanding, in their own time, and provide critical comments.

b) Quantitative data collection tools

Survey (See Appendix H)

A survey was chosen as the most applicable data collection tool for the quantitative research, as the survey was distributed to 193 preservice teachers. However, only 93 preservice teachers participated in the survey. The survey data were adapted from the CoI Survey validation study as presented in the research of Arbaugh et al. (2008). The survey was distributed after students engaged in a blended learning activity over 6 weeks. A Likert scale was used to provide response options for the statements included in the survey, wherein the range was from 1 (strongly disagree) to 5 (strongly agree). This provided the means to verify the three-subscale structure; that is, the social, teaching, and cognitive presence, of the CoI inventory (Arbaugh et al., 2008). The survey also solicited demographical information and had questions related to the access to resources. The purpose of the survey was to understand the preservice teachers' experience of blended learning approaches. Using a Likert scale provided the researcher with data that were easily quantified.

3.6.7 Data collection process

This section outlines the data collection process of the study by providing an overview of the research question addressed, the data tools employed for each question, the duration of the data collection, and the data collection dates. In addition, this section includes the challenges that the researcher experienced and how it was overcome.

a) Outline of data collection process

This study took place over 10 weeks in 2022, during semester two at a higher education institution (HEI). Preservice teachers engaged in a blended learning approach in a practical-based activity over six weeks, whereby data were collected through document analysis. Finally, a survey, as the quantitative research tool, was distributed

over two weeks to respond to preservice teachers experiences in the blended learning approach. In addition, open-ended interview questions were distributed in August 2023, and data were collected over two weeks. As noted, more than one data collection tool was used to answer the main research question, and the findings from document analysis, survey, and open interview questions, were triangulated, to reduce the possibility of bias and subjectivity. A summary of the data collection process is given in Table 3.2, according to the secondary research questions of this study.

Table 3.2: Data collection process

Secondary research question	Data collection tools employed	Data collection time frames	Data collection dates
How do Technology Education preservice teachers perceive and understand blended learning within a university context?	Open-ended interview questions	2 weeks (1 week used to analyse data)	August 2023
How are preservice teachers engaged in blended learning Technology Education courses in South Africa?	Document analysis	6 weeks (1 week used for presentations)	August 2022 – October 2022
What are preservice teachers' perceived impacts of blended learning in Technology Education courses?	Survey	2 weeks	October 2022

b) Challenges experienced during data collection

Initially, the researcher received ethical approval on 02 September 2021 (See appendix A) and then engaged with teacher educators in the Technology Education field to participate in the study. The researcher was welcomed during this process; however, when the data collection process began in the first semester of 2022, a problem was encountered due to lack of engagement from both teacher educators employing the blended learning approach in their classes, and with preservice teachers who were unwilling to participate. Another challenge that influenced the lack of engagement was unforeseen protests on the campuses regarding the return of students to face-to-face classes after the pandemic. This situation also made it difficult to observe blended

learning approaches, due to the unpredictability of the teaching and learning activities. In the anticipated total of 200 students from two campuses, only 10 responses were received from one campus.

It was then that the researcher took the initiative of involving the preservice teachers enrolled in the third-year Technology Education course that the researcher was responsible for. As the blended mode was already predetermined, and preservice teachers had already engaged in a blended learning approach in the first semester, it was difficult to collect data based on their perceptions and understanding of a blended learning approach. However, the researcher was in a fortunate position in 2023 where the preservice teachers involved in the third-year Technology Education course in the second semester had not been exposed to a blended learning approach in the first semester, nor had they previously engaged with the researcher in teaching and learning activities. Their valuable insight regarding their perception and understanding could thus be collected via an open and close-ended questions. It was unfortunate that a blended learning approach could not be studied further due to time constraints.

3.7 DATA ANALYSIS AND INTERPRETATION

Data analysis involved the “interpreting, organizing, arranging and making sense” of the data collected (Chimbi, 2018:89). In this study, it refers to the data collected from document analysis, the survey, and the open-ended interview questions. As this study is rooted in a multiple-case study design, it included the use of both qualitative and quantitative research data collection methods to provide a holistic view of the blended learning methodologies implemented in Technology Education. The data collection and interpretation process started with document analysis and the survey and concluded with the analysis of open-ended interview questions. This section details the methodologies employed for analysing both qualitative and quantitative data collected during the study. By outlining the specific techniques and processes used, this section aims to demonstrate the thoroughness and rigor of the data analysis, ensuring that the findings are robust, reliable, and contribute meaningfully to answering the research questions. This

comprehensive approach allows for a holistic understanding of the blended learning methodologies implemented in Technology Education.

3.7.1 Qualitative data analysis

For the qualitative analysis, data collected from the portfolios and the open-ended interview questions were analysed using thematic analysis and categories. As noted by Braun and Clarke (2006:6) “thematic analysis is a method for identifying, analysing and reporting patterns within data”. Data were analysed by identifying the frequency of common texts within the responses. After the portfolios were submitted, data were analysed and coded into emerging themes and patterns with the steps of the design processes (i.e., investigate, design, make, evaluate, and communicate). The analysis and coding were done using Microsoft Excel. Although a deductive approach was adopted, whereby the information received from the open-ended interview questions were used to support or contradict a blended learning approach implemented in 2022, an inductive approach was primarily used to report on the findings through the implementation of the blended learning approach. The findings from the qualitative data were further supported by those of the quantitative data. To ensure that data analysis and reduction were effectively achieved in this study, the researcher employed the six-step process of conducting thematic analysis (Meunier-Beillard, Ecarnot, Rigaud, & Quenot, 2017):

1. Familiarisation:

   This step involved the researcher being familiar with the raw data in 2022. It included preservice teachers’ engagement which were documented in an individual and group portfolio that outlined the design process followed. The portfolio required preservice teachers to indicate if additional research was necessary to supplement online learning, if they had consulted online or face-to-face resources, how they had formed groups, where they had made their project, and how communication occurred within the group (especially with regards to the platforms used or places they would meet for communication and the frequency of communication between groups members). The communication also outlined if any other person was contacted other than

those in the group. The intent of collecting this information was to understand how online and face-to-face learning spaces were used, and how they complimented each other. The results from the blended approach provided the researcher with details on the steps within the design process that could be online, face-to-face, or blended.

In 2023, preservice teachers engaged in the open-ended interview questions. Their responses outlined their perceptions and understanding of how a blended learning approach could be implemented in Technology Education. More specifically, their responses outlined their familiarity with the term blended learning, their willingness to partake in blended learning activities, their understanding of the benefits and challenges of blended learning environments, their preferred approach (i.e., online, face-to-face, blended), how they would communicate, the anticipated platforms and applications used, the frequency of classes, the use of online resources, how online and face-to-face classes can compliment each other, how performance can be assessed and how regularly feedback would be expected, and finally how their motivation, time management, and knowledge and skill gain would be affected.

2. Coding

   Coding, according to Bennet, Barrett, & Helmich, 2018:10), can be described as “selecting a chink of data and assigning a summary term or code that is meaningful in terms of your research question”. Repetitive texts within responses to the open-ended interview questions were reported on. For the individual and group portfolio submissions, the coding was done a-priori according to the design process. However, for the open-ended interview questions, the data were grouped into themes within the Technology Acceptance Model (TAM) framework, specifically (i) perceived usefulness, (ii) perceived use of ease, and (iii) attitude towards using.

3. Generating themes

4. Reviewing themes

5. Defining and naming themes

   In steps 3, 4, and 5, the researcher identified common themes from the coded data. This process reviewed and defined data to ensure that all themes were easily understandable and applicable. Fortunately, data from the portfolios were already defined and named according to the steps of the design process, and data from the open-ended interview questions were defined and named according to the Technology Acceptance Model (TAM) framework. However, further themes were identified within the TAM framework. Namely under attitudes towards using, this included assessing personal progress and performance, maintaining motivation and interest, managing time and workload, and gaining the necessary technological knowledge and skills. These all aligned with the questions asked. Furthermore, data collected and analysed were validated through member checking to ensure that the information was accurate.

6. Writing up

   Finally, a comprehensive report was written about the themes identified in the portfolio and open-ended interview questions. This report is be presented in chapter 4 of this study.

3.7.2 Quantitative data analysis

For the quantitative analysis, the CoI survey was adapted from its original 34-item format to a 30-item survey. The CoI survey has been thoroughly validated in research as a measurement of the extent to which respondents engage in online learning. The CoI survey, consisting of Likert scale statements, was distributed to gather insights into Technology Education preservice teachers' experiences with blended learning. The survey was structured into four sections aligned with the theoretical framework: (i) demographic characteristics, (ii) access to resources, (iii) common concerns regarding blended learning activities, and (iv) Community of Inquiry, focusing on teaching, cognitive,

and social presences. To assess the internal validity of the survey, Cronbach's Alpha was calculated.

Data analysis involved both descriptive and inferential statistics. Descriptive statistics, as noted by Mishra, Pandey, Singh, Gupta, Sahu, and Keshri (2019:71), descriptive statistics can be defined as "a statistical method to summarizing data in a valid and meaningful way". These statistics allow the researcher to present data sets in more meaningful ways, such as through tables and graphs, which are simple to understand and interpret. Factor analysis was also employed to identify distinct and reliable factors from the survey data, as suggested by Arbaugh et al. (2008). Given the large number of participants, factor analysis helped reduce multiple variables into more distinguishable factors. Furthermore, inferential statistics were used to make broader inferences about the population. As noted by Croucher and Cronn-Mills (2024), inferential statistics include tests of differences (such as ANOVA) and tests of relationships (such as correlation). These methods enabled the researcher to draw data-driven conclusions and understand the broader impact of the findings.

Data were initially analysed using Microsoft Excel, utilizing the "Analyze Data" feature and available formulas. Thereafter, IBM SPSS Version: 29.0.0.0 (241)was used to confirm the data and perform inferential statistical analyses. Means and standard deviations for items related to teaching, cognitive, and social presences were calculated. Additionally, the average mean for each section and Cronbach's Alpha were calculated to enhance the findings and improve reliability. Statistically significant differences in each presence were then tested using t-tests, followed by ANOVA to analyse access to resources and common concerns regarding blended learning activities according to the various items within the CoI survey, and further analysed using post hoc Tukey HSD.

3.8 TRUSTWORTHINESS OF THE STUDY

While this research study grounded itself in both qualitative and quantitative data, as a means of ensuring that the data collected were rich and promoted understanding, it should be noted that the research study contains more elements of qualitative data than

of quantitative data. Williams and Morrow (2008:578) list three major categories of trustworthiness to which qualitative research must conform:

Integrity of the data: ensuring data integrity is imperative to any study. It guarantees that the accuracy and reliability of the research findings. As mentioned in Sections 3.6.3 and 3.7.2, this study contains similar elements to the study conducted by Arbaugh et al. (2008). In addition, rich and thick descriptions were sought as a means to clearly articulate the methods that underpin the study, as well as that which was found in the data collection strategies implemented. Furthermore, as Williams and Morrow (2008) recommend, direct quotations by participants will be provided in the articles, as a means of presenting participants' voices and perspectives in the study. This contributes towards the authenticity of the data. In addition, the researcher ensured that data collected was stored securely with passwords, that only the research had access to. By upholding these principles, the study aims to contribute credible and valuable insights, reinforcing the importance of ethical and precise data management in research.

- Balance between reflexivity and subjectivity: a major concern in research is the gap between what the participants say, and what the researcher understands. This concern relates to the researcher's personal biases and is discussed in Section 3.8.1. Williams and Morrow (2008:279) refer to the researcher's self-awareness, "wherein the researcher remains self-reflective and able to identify, as clearly as possible, what comes from the participant and what comes from the researcher". This awareness is referred to as reflexivity and is supported by the process of confirmation (member checking) and the triangulation of data (see section 3.8.3).
- Clear communication of findings: in line with Williams and Morrow (2008) argument for clear communication of findings, this study presents its findings in a manner that outlines its relationship with the literature. More specifically, this study provided an in-depth literature review in Chapter 2, as a means of taking note of relevant theory and empirical research that both support and contradict the findings of this study found in Chapter 4.

Supplementary to the aforementioned strategies to ensure trustworthiness, the following sections discuss further strategies that were employed to ensure that the research presented in this thesis contains minimal elements of bias and subjectivity. The topics of the following sections are the researcher's personal biases, prolonged engagement in the study, and data triangulation.

3.8.1 Researcher's personal biases

As the researcher, who was also the lecturer in this study, biases needed to be eliminated. Thus, the researcher emphasized the anonymity and confidentiality of the participants' responses. By assuring the preservice teachers that their responses would not affect their final mark or their academic standing within the course, the researcher aimed to minimize social desirability bias. As noted by Kang and Hwang (2023), maintaining anonymity and confidentiality helps protect participants' privacy and establish trust.

For the document analysis (portfolios), preservice teachers were required to personally reflect on the topic, as this was necessary for data collection; however, special attention was paid to avoid questions that would dictate responses, or steering information given by the preservice teachers or the teacher educator, which might have led to their falsifying or fabricating information. Furthermore, the CoI survey was used as a well-established instrument designed to measure the quality of online and blended learning tools. Thus, the CoI survey contributed to the mitigation of biases in by providing a validated and reliable measurement tool and ensuring the neutrality of questions.

For the open-ended interview questions, the researcher provided clear instructions and support for using the online platform to ensure that all participants, regardless of their digital literacy levels, could respond effectively. An extended time limit was also given to allow preservice ample time to respond. In addition, neutral language was used in the open-ended interview questions to avoid leading participants towards certain responses.

Finally, if the information was not understood by the researcher, or the information was ambiguous; the researcher ensured that a follow-up was done with the source of the

information to avoid misinterpretation. At all times, the researcher attempted to be clear and transparent and to avoid any misunderstandings. The ethical issues that are discussed in Section 3.9 were constantly referred to as a guideline.

3.8.2 Prolonged engagement

The initial phase of the study (i.e., phase 1 outlined in section 3.5) took place over 10 weeks, starting in the middle of August and ending in October. A total submission of (two) preservice teacher portfolios and one survey were conducted, as discussed in Section 3.6.6. The prolonged engagement was intended to fully understand the blended learning approaches used and to determine if they corresponded with the expected outcomes over a semester. Prolonged engagement also allowed the researcher to establish rapport with the participants, thereby building trust. Moreover, the extended engagement period facilitated a deeper immersion into the educational environment, enabling the researcher to gather rich, contextual data. This ensured that the findings were not only reflective of a single point in time but also captured the ongoing interactions and experiences of preservice teachers throughout the semester.

3.8.3 Data triangulation

Document analysis, a survey, and the open-ended interview questions were the main data collection tools used in this study. As stated by Ozturk (2012:297), “triangulation refers to the application and combination of several research methodologies in the study of the same phenomenon”. The process of triangulating data provided a means to uncover key findings and themes in the data. As mentioned by Williams and Morrow (2008:578), “[i]n addition to quality, quantity of data is key to filling out categories or themes in such a way that the reader is able to grasp the richness and complexity of the constructs under investigation”. It is for this reason that a sequential, exploratory design was used.

According to Heale and Forbes (2013), the purpose of triangulation is to confirm findings and to provide a more comprehensive depiction of the results. It increases the

validity and credibility of the study and ensures that biases arising from a case study can be overcome (Noble & Heale, 2019). In addition, the results of triangulation can converge findings, differentiate between them, and cause findings to complement each other (Heale & Forbes, 2013). Triangulation not only confirmed the findings but also provided a richer, more nuanced understanding of the data. By combining multiple methods, the study was able to cross-verify results, reducing the likelihood of bias and increasing the reliability of the conclusions.

3.9 ETHICAL CONSIDERATIONS

As stated by Resnik (2012:329), ethics can broadly be defined as “guidelines and codes of conduct adopted by professional associations [that] are usually framed in terms of rules, duties, or responsibilities”. The subsections that follow, discuss the measures that were executed in this study.

3.9.1 Permission to carry out research (See Appendix A and D)

The researcher obtained permission from the HEI to study, observe, and record the implementation of the blended learning approaches that support student success in selected courses. Permission was also requested from the head of an institution/department in the faculty. All findings are open public scrutiny; however, the identity of all participants remain confidential.

3.9.2 Informed consent and voluntary participation (See Appendix E and H)

The researcher indicated the nature of the procedure and intention of the study, and assured participants that their identities would be safeguarded. Participants were able to terminate their participation at any point. Under no circumstance was it the researcher’s intention to deceive participants. Participants were also informed about the benefits of the research. Data collection activities included preservice teacher portfolios, a survey, and open-ended interview questions. In all cases, the identities of the

participants were blurred. Data were collected and stored securely with passwords, to which access was limited to the researcher only.

3.9.3 Anonymity and confidentiality

Owing to the in-depth nature of the research, it is important to protect the participants of a study and to ensure that they remain anonymous. Arifin (2018:30) emphasises that participants must be “competent to consent”; the participants must consent freely to taking part in the study, and it must be ensured that the participants clearly understand the nature of the study. The preservice teachers who participated in the survey were required to fill in their student numbers at the start of the survey. This information was used to engage with the participants in clarity-seeking questions or for further understanding. However, these participants were assured that this was required only for administrative purposes and that their names would not be mentioned anywhere in the study. For discussion purposes, these preservice teachers would be identified by numbers, which was the only link to the data provided. Allocating numbers ensured that the preservice teachers’ perceptions, understanding, engagement, and experiences could be compared across data collection tools. The participants were informed that participation was voluntary, and that they could choose to suspend participation at any point of the study, should they no longer wish to participate.

Furthermore, all evidence gathered from document analysis, survey, and the open-ended interview questions were accessible only to the researcher and supervisor. This evidence was stored in a secured folder.

3.9.4 Honesty and truthfulness

As with any other research study, this study intended to contribute to and expand on the existing body of knowledge. Falsifying or fabricating data is highly unethical and should always be avoided. As highlighted by Chimbi (2018:102), it is ethical misconduct to “suppress, falsify or invent findings”. The researcher, to the best of their knowledge, presented the findings in this study with truthfulness and honesty. It is assumed that the

participants in this study engaged with the same stance; that is, without exaggeration or falsification.

3.10 CONCLUSION

Two cases constituted towards this multiple-case study design that underpinned the research methodology of this study. This research design was found to be best suited for a study that had as its primary focus the blended learning approaches employed in a third-year Technology Education course. The research sites and target populations, which were unique to this study, were addressed in this chapter, and the researcher discussed how participants were chosen. This chapter provided the details of the data collection process and discussed the three main research strategies used, namely document analysis, survey, and open-ended interview questions.

Furthermore, the chapter reported that themes had emerged from the empirical data that had been captured, and described how these data were coded and synthesised. The trustworthiness of the study and ethical considerations were also discussed before the chapter concluded.

SECTION B:
PRESENTATION OF THE THREE PUBLISHABLE ARTICLES

ARTICLE 1: UNDERSTANDING BLENDED LEARNING IN A PRACTICAL-BASED COURSE: INSIGHTS FROM TECHNOLOGY EDUCATION PRESERVICE TEACHERS IN A SOUTH AFRICAN UNIVERSITY

Introduction

This article was prepared using the guidelines for the African Journal of Research in Mathematics Science and Technology Education (AJRMSTE) (cf. Appendix I). It addresses the first research question which ask, “How do Technology Education preservice teachers perceive and understand blended learning within a university context?”. A qualitative research methodology was implemented whereby a total of 50 purposefully selected preservice teachers partook in an open and closed ended interview questions. The open and close ended interview questions were distributed via Google Forms. Furthermore, the Technology Acceptance Model (TAM) framework was used to evaluate their responses. From the results, it was found that the majority of participants understood the term blended learning and could identify the possible benefits and challenges. This indicates that participants could identify the usefulness of the blended learning approach. In addition, the results suggested a possible blended learning module.

Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university

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Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university

Blended learning is a teaching and learning approach that has recently gained momentum. The approach combines online and face-to-face classes to enhance learning outcomes Despite the widespread implementation of blended learning in higher education institutions, there is a significant research gap regarding preservice teachers' perceptions and understanding of this approach in practical-based courses such as Technology Education. This study aims to fill this gap by providing insights into how Technology Education preservice teachers perceive and understand blended learning, thereby contributing to the existing literature and informing future educational practices. This qualitative study therefore aimed to contribute to the literature by exploring how Technology Education preservice teachers perceive and understand blended learning within a university context. A cohort of 50 Technology Education preservice teachers, from one higher education institution, were purposefully selected to respond to open-ended questions. The Technology Acceptance Model framework was used to evaluate their responses. The framework was found best suited as it models how users come to accept and use technologies. The Technology Acceptance Model framework incorporates three factors, namely perceived usefulness, perceived ease of use, and attitude towards using. After data collection, data were analysed using thematic analysis and coded into the Technology Acceptance Model framework factors. It was found that participants had an overall positive perception towards the possible implementation of blended learning in Technology Education, specifically with regards to the usefulness and ease of using technologies. Their responses further provided insight into their attitudes, indicating how the approach can be designed and strategically implemented to ensure that active learning takes place and learning outcomes are met.

Keywords: blended learning, higher education institutions, information and communication technologies (ICTs), preservice teachers, Technology Education

Introduction

The COVID-19 pandemic caused abrupt changes in the education system. Higher education institutions (HEIs) were required to shift teaching and learning from face-to-face to online in

response to managing the spread of the virus. As face-to-face teaching and learning activities resume, the shift provides an opportunity for HEIs to reconsider how to best incorporate the use of online technologies to improve teaching and learning outcomes. Thus, the implementation of blended learning approaches is swiftly gaining momentum (Janse van Rensburg & Oguttu, 2022; Yu et al., 2023).

Blended learning combines online learning with traditional face-to-face learning. Several studies have examined preservice and in-service teachers' perceptions of blended learning, generally reporting positive attitudes towards its adoption (Attard & Holmes, 2020; Edannur & Marie, 2017). These studies highlight benefits such as improved access to resources and enhanced learning outcomes. They acknowledge opportunities such as potential benefits of information and communication technologies (ICTs) in future classes, improved access to online resources, promotion of visualisations and manipulation of concepts, enhanced understanding through applications, improved content knowledge, and opportunities for learners to engage in self-paced learning (Attard & Holmes, 2020; Edannur & Marie, 2017; Janse van Rensburg & Oguttu, 2022; Yilmaz & Malone, 2020). However, the success of the approach depends on the teacher's ability to effectively integrate online and face-to-face modes. Literature highlights various aspects of teaching and learning methodologies and teacher-student interaction. However, significant challenges remain, such as the absence of policies for implementing blended learning, inadequate training, limited or no access to laboratories, and a lack of engagement due to low confidence (Gumbo, 2020; Mapotse, 2017; Mudenda et al., 2023; Mulaudzi et al., 2023). These challenges critically impact the progress towards effective blended learning implementation in Technology Education courses. As noted by Edannur and Marie (2017), "a critical component in meeting teachers' technology needs is responding to teachers' perception … towards using the technologies

in teaching" (p. 32). Despite the growing digital literacy amongst preservice teachers, there is a need for high-level digital literacy self-efficacy (Aslan, 2021) to effectively adapt to the current digital age. Thus, understanding how preservice teachers perceive the use of technologies in classes will impact how the blended learning approach can be implemented. This study aims to address the following research questions: How do Technology Education preservice teachers perceive blended learning?

Theoretical framework

The Technology Acceptance Model (TAM) was employed to understand the factors influencing preservice teachers' acceptance of blended learning. By focusing on perceived usefulness, perceived ease of use, and attitudes towards using technology, the TAM provides a comprehensive framework to evaluate and enhance the implementation of blended learning in Technology Education.

The TAM posits that user motivation can be explained by three factors, namely (i) perceived usefulness, (ii) perceived ease of use, and (iii) attitude towards using (Granić & Marangunić, 2019). Perceived usefulness refers to the user's belief that the particular system will increase or enhance job performance (Granić & Marangunić, 2019; Murillo et al., 2021). This factor directly impacts the user's intention to use the technology, based on the perceived benefits it can offer. As in this study, perceived usefulness refers to how useful preservice teachers believe a blended approach would improve their self-efficiency and productivity in a Technology Education course. The perceived ease of use factor refers to the user's belief that the particular system would be easy to use (Granić & Marangunić, 2019; Murillo et al., 2021), such as preservice

teachers' belief that educational technologies that are used in a blended approach will be easy to use. Lastly, attitude towards using refers to whether the user accepts or rejects the system (Murillo et al., 2021). This attitude is shaped by both perceived usefulness and perceived ease of use, ultimately influencing preservice teachers' attitude towards engaging in a blended approach.

The application of the TAM was found suitable as the framework aims to explain how users come to accept and use technologies. By applying the TAM, the researchers were able to determine the attitudes of preservice teachers towards a blended learning approach implemented in Technology Education. Thus, the TAM not only provided a theoretical basis for understanding preservice teachers' acceptance of blended learning but also offered practical guidance for designing blended learning environments that align with the needs and preferences of preservice teachers. This alignment is essential for fostering positive attitudes towards technology use in education and enhancing the overall effectiveness of blended learning approaches.

Literature review

This literature review section explores existing research on preservice teachers' perceptions and understanding of blended learning. It examines key sub-themes such as blended learning in higher education, the benefits and challenges associated with blended learning, and Technology Education.

Blended learning in higher education

Blended learning is defined as the integration of e-learning with traditional classroom learning in one framework (Ayob et al., 2023). The approach combines asynchronous and synchronous learning, and further accounts for the pace and place of learning (Halverson et al., 2023).

Furthermore, Yang et al. (2021) defined blended learning as an instructional design that "facilitates the benefits of technology, paired with face-to-face instruction, to address the variance in student learning" (p. 1). The purpose of including technology is to maximise the instructional and technological support to ensure that learning outcomes are obtained. As noted by Driscoll (2002), blended learning can "mean different things to different people" (p. 1). The approach can be implemented in various ways, whereby pedagogical approaches, ICTs used, tasks and activities, and web-based technologies differ in the way they are combined (Driscoll, 2002). Thus, in essence, blended learning is simply and broadly defined as the combination of online and face-to-face teaching and learning activities.

In 2020, online teaching approaches gained momentum within HEIs as a result of the COVID-19 pandemic. Many protocols were implemented to manage the spread of the virus. As a new norm is entered, whereby normal community life continues with stricter health measures, face-to-face teaching and learning activities resume. However, the potential impact of online and blended learning approaches is evident within HEIs.

Benefits and challenges of blended learning

Studies conducted on blended learning have noted the various benefits and challenges of implementing a blended learning approach. The approach offers many benefits, such as increased learning outcomes, autonomous learning, overall satisfaction, active learning, interaction, flexibility, and motivation (Chan, 2019; Janse van Rensburg & Oguttu, 2022; Ketsman, 2022; McGuinness & Fulton, 2019, Namyssova et al., 2019; O'Connor et al., 2011). These studies highlight the ability to access course tools and materials anywhere, complete assessment activities at one's personal pace, and engage in modern digital technologies. Positive perceptions are often associated with increased engagement and satisfaction, while negative perceptions can hinder the

effectiveness of blended learning.

However, the approach also presents challenges, such as lack of or limited resources, inadequate training, lack of support, increased responsibility for own learning, low media utilisation, insufficient data or low connectivity, low interaction amongst participants, misalignment with learning expectations, confusion regarding how to implement the approach, and disordered time allocation (Abdurahman & Ahmad 2022; du Toit & Pool, 2020; Janse van Rensburg & Oguttu, 2022; Tshablalala et al., 2014; Ubah et al., 2020; Zimba et al., 2021). The approach can be implemented in various ways, with multiple benefits and challenges highlighted. This suggests the need to clarify preservice teacher expectations to mitigate the negativity and confusion that influence the success and effectiveness of the blended learning approach.

Technology Education

Technology Education is offered to preservice teachers at HEIs. The course aims to develop preservice teachers who can teach the subject at a senior phase level at schools. Similarly, the subject aims to develop learners who can respond to the technological needs of society (South Africa. DBE, 2011). The course and the subject aim to develop technological literacy, enhance creativity, encourage critical thinking, and improve problem-solving skills (Ankiewicz, 2020; Gumbo, 2020; Jones et al., 2016; Mapotse, 2017; Mulaudzi et al., 2023; South Africa. DBE, 2011). Preservice teachers will need to be subject content experts in fundamental topics relating to theory, drawings, and practical tasks. Preservice teachers must be able to teach and engage their learners in the design process, which can be described as a sophisticated thinking approach and application of their technical knowledge (Hynes, 2010). This process outlines the practical domain and is necessary when engaging learners and students in problem-solving tasks. The process provides a step-by-step guide that contributes towards the overall goal. Within these steps, the application of

theoretical knowledge and drawing skills will support creativity, efficiency, and quality.

Within teacher training programmes, Technology Education courses require enrolled students to "develop deep content knowledge and strong pedagogical skills" to perform within the 21st century (Mulaudzi et al., 2023, p. 133). However, there is a scarcity of research regarding professional development within South African Technology teachers (Gumbo, 2020). In addition, it has been noted that there are Technology Education in-service teachers who are underqualified to teach the subject (Gumbo, 2020; Mapotse, 2017). This poses a problem and highlights the need for effective teacher training programmes that keep up to date with modern advancements. As noted by Mapotse (2017), there is a need for teacher training programmes to ensure that graduates "are well prepared to use new tools for learning" (p. 687). This is further supported by Pappa et al. (2024), who outlined the challenge of teacher training and professional development programmes that do not adequately, or effectively, enhance the subject. This highlights the need for preservice teachers to engage in activities that replicate the importance of the subject and its context within the modern world. Thus, offering blended learning as a teaching and learning approach in Technology Education could close this gap. This literature review indicates that blended learning offers significant benefits for preservice teachers. However, the need for effective instructional design must be addressed to maximise its potential. As such, it has become imperative to understand preservice teachers' perceptions and experiences with blended learning in order to keep up with contemporary society. This study aimed to fill the gap by exploring the perceptions and experiences of Technology Education preservice teachers, providing insights for more effective implementation of blended learning in practical-based courses.

Methodology

A qualitative research design was chosen to gain in-depth insights into preservice teachers' experiences and perceptions of blended learning. Furthermore, an interpretivist research paradigm was used to provide insight into Technology Education preservice teachers' views of blended learning in a university context. According to Pervin and Mokhtar (2023), the interpretivist research paradigm is "based on the assumption that social reality is shaped by human experiences" (p. 51). This paradigm was thus the best fit, as it allowed the researchers to better understand the complexities of a blended learning approach as perceived and understood through the social interactions and practices of preservice teachers.

Participants were selected using purposeful sampling techniques. Technology Education preservice teachers in their third year of study from a single HEI were invited to participate. A case study, which included 50 preservice teachers who had not engaged in a blended learning approach within Technology Education during their undergraduate studies, was employed. As noted by Crowe et al. (2011), a case study explores "an event or phenomenon in depth and in its natural context" (p. 1), making it suitable for this study. Data were collected online through open-ended interview questions developed through the use of existing literature and expert feedback. Ethical approval was obtained, and participants provided informed consent. Data collection spanned over two weeks and data were analysed using descriptive and thematic analyses. More specifically, themes were identified within question groups guided by the TAM framework. Member checking was employed by sharing findings with participants for validation.

Findings

The findings of the study are grouped according to the TAM framework. Perceived usefulness includes preservice teachers' perceptions of blended learning in relation to the definition, the benefits and challenges perceived, and thoughts on how the approach can be implemented in practice. The second factor, perceived ease of use, includes the expected frequency of online and face-to-face classes, how these modes of instruction complement each other, and the anticipated applications that can be used are discussed. Lastly, attitudes towards using, focuses on optimising the blended learning approach. Critical aspects such as monitoring personal progress, maintaining motivation and interest, managing time and workload, and ensuring that the necessary skills and resources have been acquired is focused on. By exploring these sub-headings, the researchers aimed to provide a comprehensive understanding of the intricacies involved in implementing a blended learning approach in Technology Education.

***Perceived* usefulness**

Preservice teachers' perception of blended learning is largely accounted to their familiarity and understanding of the approach, positive learning experiences can contribute towards positive student engagement. Participants were asked to "define blended learning in your own words". This provided the researcher with a basis on how preservice teachers viewed blended learning. Notably, four participants did not provide a definition. One participant (P11) indicated that blended learning was "online learning". Amongst the responses, blended learning was defined predominantly as the combination of online/electronic and face-to-face teaching and learning activities. These responses are as follows:

P22: *Blended Learning is an approach to education that combines online education materials and physical face-to-face classes.*

P36: *Blending different kinds of learning to teach one thing, it can be online and contact.*

Responses from two participants indicated additional insight into their definition. These responses were that blended learning was (i) the use of online materials to support face-to-face learning and (ii) the teaching of one section both online and face-to-face. Therefore, based on participants' responses, this study resolves that blended learning can be defined as the combination of online and face-to-face activities. This includes, but is not limited to, teaching activities and learning activities and sharing and using educational materials. It also involves one or more learning unit.

Furthermore, participants were asked "What would you say are the benefits of Blended Learning in Technology Education? Provide at least 3 benefits.". One participant (P7) indicated that it would make information readily and easily accessible.

P7: *It makes information available for everyone, even for those who could not make it to class. Students who did not understand in class can go and watch the recorded online class for further understand[ing]. In terms of studying for a test or exam, students get all [the] lessons which will help in revising and studying*.

Amongst other responses were increased flexibility, exposure to different learning platforms and learning environments, enhanced learning, increased interaction and improved engagement, efficiency, easily accessible learning materials, learning at own pace and understanding, and enhanced computer literacy skills. Furthermore, preservice teachers' recognition of the potential of blended learning and the potential positive impact is a good indicator of their readiness to for the integration of such an approach. Accordingly, the following statements further contribute to the benefits of blended learning in a Technology Education course, this

includes accommodating those who are introverts, exposure to various forms of learning, reviewing lessons and improving on the learning environment. The responses are as follows:

P11: *Introverts can ask questions freely without being shy*. *You can express what you learned in the chat box*.

P12: *Students get to learn and adapt [to] various forms of learning, which they can also introduce at schools as innovations.*

P13: *Students can get better acquainted with learning technology [education] online. Online lectures are often recorded so students have the opportunity to review the lesson if they don't understand something.*

Common challenges that were experienced by participants were network issues, load-shedding, cost (devices and data), lack of digital literacy, resistance towards the approach, lack of resources, failure to focus, inadequate training, lack of engagement, lack of time management skills, plagiarism, and confusion that decreased motivation. The statements below further respond to the challenges of implementing a blended learning approach in a Technology Education course. This includes challenges with graphical communication, increased workloads, distractions, digital illiteracy, difficulty finding a balance between online and face-to-face, and lack of discipline. The responses are as follows:

P6: *It becomes a challenge when it comes to drawings.*

P7: *An increase in workload as students put work for later. [Students] avoid face-to-face classes, so that they cannot be asked questions.*

P11: *Students log in to the class and focus on other things.*

P12: *Adapting to this kind of learning may require some skill or effort such as self-responsibility, the ability to use technological devices, and self-regulation which sometimes is not easy to do.*

P39: *Technology is more of a practical subject so it requires more face-to-face interaction, some students might experience difficulty in establishing a balance between the two teaching methods.*

P41: *Skipping classes in the name of "I'll listen to the recordings".*

The responses to the benefits and challenges of implementing a blended learning approach highlight common responses in accordance with the literature. However, the challenges also highlight matters specific to Technology Education. Aspects such as the teaching and learning of graphical communication may be difficult to achieve online. Similarly, practical-based tasks are seen to require more face-to-face interaction and thus should be taught face-to-face.

In response to this, it was noted that Technology Education is divided into three learning domains, namely theory, drawing, and practical. Participants were asked which approach they preferred for each of the learning domains. The responses are displayed in Table 1.

Table 1: Preferred approaches in Technology Education learning domains

Learning domain	**Online**	**Face-to-face**	**Blended**	**Total**
Theory	26	17	7	50
Drawing	5	41	4	50
Practical	9	32	9	50

The data indicate that participants preferred an online approach to theory classes and face-to-face approach to both drawing and practical classes. It is interesting to note that few participants indicated preference of a blended learning approach for each learning domain. However, responses to the question, which approach would you prefer in Technology Education? indicated that 64% of participants preferred blended learning, 28% preferred purely face-to-face, and 8% preferred purely online. Further analysis indicated that the majority of those who preferred a blended learning approach were participants who indicated a preference for either online or face-to-face for each learning domain. Thus, the blended learning approach holistically expected in a Technology Education course is seen to be a combination of online theory classes and face-to-face drawing and practical classes. Participants were also asked why a blended learning approach should be implemented in Technology Education. Amongst the responses, participants indicated that there is limited time in teaching and learning activities, keeping up with the 21st century, and accommodating various personalities, were in support of a blended learning approach. The following was stated:

P12: *Blended learning in technology may be necessary for some theory lessons; since we have a limited time in a physical class, online platforms such as Blackboard would come to assist, where we learn and the lesson is recorded such that we are able to listen later and follow in the pace that complements our understanding. The other part of technology, which is graphic communications, is well suited by contact classes for clear demonstrations and quick questions for clarity. Blended learning should therefore be implemented in technology for those reasons.*

P40: *I think it should be implemented because most things nowadays are online..*

P47: *To encourage everyone to participate in class and share their thoughts, since some may feel embarrassed giving a wrong answer in a face-to-face class*.

These responses align with the benefits of blended learning approaches. This finding indicates that the participants in the study recognised, acknowledged, and understood the advantages of the implementation of a blended learning approach in Technology Education. This further indicates the potential effectiveness of the blended learning approach in enhancing learning outcomes.

Perceived ease of use

Accessing online classes and resources is an imperative part of the blended learning approach; how preservice teachers access the information will indicate the kind of devices that should be considered. Devices such as laptops and smartphones were common answers in participants' responses. Other devices mentioned include tablets, desktops, and iPads. Furthermore, 26 participants indicated that they would expect to have online classes once a week, whereas 22 participants indicated that they would expect to have online classes twice a week. The remaining two participants indicated that they expected to have online classes thrice a week. Participants were also asked how often they would expect to have face-to-face classes per week. Of the 50 participants, 24 indicated once a week, 18 indicated twice a week, 3 indicated thrice a week, and 5 indicated that they would expect to have face-to-face classes 4 times a week or more. Table 2 outlines these results.

Table 1: Preferred frequency of classes per week

Frequency	**Online classes**	**Face-to-face classes**
Once a week	26	24

Twice a week	22	18
Thrice a week	2	3
Four times a week or more	0	5
Total	**50**	**50**

The results therefore indicate that participants expected to have online classes once or twice a week and face-to-face classes at least once a week. Correspondingly, participants were asked how online and face-to-face activities would complement each other. Responses were identified under the following themes:

- Clarification through collaboration

Face-to-face classes could be used to discuss and clarify what was said in the online class. Students can complete online activities and readings at their own pace, and then supplement understanding face-to-face.

- Improved outcomes

Online classes can be used for the theory component and face-to-face classes can be used to apply the knowledge in practice. Similarly, face-to-face classes will also be used for drawings. This further aligns with the enriched virtual model whereby preservice teachers would be required to attend face-to-face graphical communication classes and possibly theory classes online.

- Flexibility and convenience

Online and face-to-face classes can be conducted simultaneously, allowing preservice teachers to attend according to their preferences.

- Improving research skills and technological literacy

It was indicated that face-to-face classes can be used to convey content and that preservice teachers would then do research online until the content is understood. Furthermore, participants indicated that they could use online resources to access the LMS, improve their digital literacy skills, and engage with peers and the instructor(s).

The following applications were noted for engagement with their peers and instructor(s). The items are displayed below in terms of hierarchy, starting from the most frequently stated application to the least frequent:

(1) Emails,
(2) Blackboard (Blackboard Collaborate, Discussion boards, Blackboard Groups),
(3) WhatsApp,
(4) Microsoft Teams,
(5) Zoom,
(6) Skype, and
(7) social media.

Furthermore, participants recommended online theory classes and face-to-face drawing and practical classes. The implementation would require that the online and face-to-face classes complement each other by providing clarification and increasing collaboration, improving learning

outcomes, providing flexibility and convenience, and improving research skills and technological literacy. The findings also indicate that the top three most frequent applications for communication were emails, Blackboard, and WhatsApp, whereby either a laptop or smartphone would be used.

Attitudes towards using

As blended learning can be implemented to create dynamic and engaging teaching and learning environments, understanding preservice teachers' attitudes assists in understanding how this can be achieved. Below are participants' perceptions of the various aspects that are critical to the success of the blended learning approach.

Assessing personal progress and performance

Participants were asked how they assess their progress and performance in a blended learning approach. They indicated that they would create assessments to test their knowledge, create weekly plans on what should be attained/understood, create study timetables, reflect on the course content, monitor summative assessment marks, redo assessments for improvement, communicate with lecturers and tutors often, and/or create rubrics. In line with this, these responses were found to be interesting in assessing personal progress and interest:

P16: *By checking my concentration and comprehension in both [online and face-to-face], my marks then find ways to improve or change certain methods either for online, where my working space is, or face-to-face when to note down information and listen to understand.*

This indicates a view that the approach should be an option, rather than either online or face-to-face only. Furthermore, it was interesting to note that some responses indicate that personal progress and performance were to be monitored and provided by the lecturer:

P23: *By checking on my Blackboard if the lecturer posted about our performance regarding*

blended learning.

P24: *By asking my lecturer how I am doing.*

Therefore, whilst it is noted that personal progress and performance are assumed to be in the hands of the preservice teachers, the instructor also plays a key role.

Maintaining motivation and interest

Participants indicated that their motivation and interest will be affected by the engagement with technologies and access to resources (positive responses towards having access to online resources, recordings, and assessments). Their interest and motivation would also be affected by ease of communication (ease of communication with peers and instructors), suitable learning environments (ability to learn from anywhere), and interest in learning through different learning approaches. The following comments outline a positive response to their motivation and interest:

P7: *Shifting my learning from formal learning to online involves [a] lot of knowledge in how technological devices work, meaning in a way [I] am also improving my technology skills and grow my interest in how technology works. I will never be late for class if I can even attend on my phone.*

P12: *Graphic communications are challenging, and I would always want to engage because I like challenges. This would be a motivation; the fact that I can catch up on theory classes would be very interesting and motivate me to attend classes anytime.*

Furthermore, some participants indicated that a blended learning approach would not affect their motivation or that they did not know how it would be affected. The participants also commented that there is a lack of incentive when learning online, and that it can be challenging. The responses are as follows:

P11: *Studying online makes me lazy. [It will] increase [the] level of procrastination.*

P44: *Blended learning can be challenging. I can feel overwhelmed by the amount of technology I will be using.*

Managing time and workload

Participants indicated that a blended learning approach would save time, as they would not need to prepare for face-to-face classes; they could simply log onto the LMS using their digital devices. Furthermore, participants indicated that it would help with time management, accessibility, interest and engagement, and convenience. The responses are as follows:

P3: *It can help manage time and workload by offering flexibility to access materials online, allowing you to pace your studies. [Face-to-face] sessions provide guidance and interaction, enhancing understanding. This balance promotes effective time management and accommodates diverse learning styles.*

P7: *It is easier to work at the comfort of my home and for someone that is not staying closer to campus. I arrive to class tired and become less active. Therefore, blended learning will help me attend classes online with all the energy.*

P48: *I will be able to complete the online component of my learning at a time and place that is convenient for me. This can help to reduce stress and pressure, as I will work around other commitments and responsibilities. Additionally, the online component can often be broken down into smaller, more manageable tasks, which can help me to stay on track and not get overwhelmed by large assignments or projects.*

Participants also indicated that they have clashes with other courses. A blended learning approach would thus assist them in managing their workload, as they would be able to access learning materials and recordings at a later stage. This would also allow them to refer to recordings multiple times to ensure that they understand the content.

Gaining the necessary technological knowledge and skills

As Technology Education is a practical-based course, it can be challenging to ensure that preservice teachers are gaining the necessary knowledge and skills. Amongst the responses, participants indicated that they would set clear goals, do self-assessments, ask the instructor, ensure that they attend classes, contact their peers and instructor when needed, and review course outcomes to ensure that they are on par.

Therefore, optimising these aspects can empower preservice teachers with positive attitudes to thrive in the blended learning approach implemented in Technology Education. Lastly, the open-ended interview questions concluded by asking participants if they were excited about the possibility of a blended learning approach implemented in Technology Education. In this regard, 66% were excited, 30% were unsure, and only 4% were not excited.

Discussion of the findings

The study aimed to understand how Technology Education preservice teachers perceive and understand blended learning. The findings have important implications for practice and policy. Positive perceptions suggest that HEIs should integrate blended learning more extensively, aligning with studies by Attard and Holmes (2020) and Edannur and Marie (2017), which highlight the value of flexibility and accessibility. Additionally, this study highlights the need for targeted training programmes to enhance digital literacy amongst preservice teachers. Such training

programmes can equip in-service and preservice teachers with the necessary skills to effectively integrate ICTs into their blended learning classes and overall teachings, thus improving the quality of education. Policymakers should develop clear guidelines and provide the necessary resources to support the implementation of blended learning. These findings are based on the TAM framework, which was found most applicable in this study as it serves as a tool to predict and explain preservice teachers' attitudes towards blended learning. As noted by Taherdoost (2018), the TAM framework can incorporate additional variables such as training requirements, user participation and inclusion in the design and implementation, and system characteristics.

Multiple studies have reported that preservice teachers' perception of the usefulness of blended learning is largely accounted to their familiarity and understanding of the approach (Dumford & Miller, 2018; ElSayad, 2023). As noted by ElSayad (2023), blended learning can be defined as the combination of online and face-to-face activities, which aligns with the literature (Ayob et al., 2023; Drysdale et al., 2013; Yang et al., 2021). However, in support of the views of Driscoll (2002), who had outlined that blended learning can include various definitions that are dependent on the person, the findings of this study suggest that blended learning (i) is online classes supported by face-to-face teaching (as opposed to the later), and (ii) can be presented in a HyFlex learning mode (i.e., online and face-to-face simultaneously). Notably, four participants indicated that blended learning is online learning and one participant did not provide an answer. This further highlights the need to clearly explain what a blended learning approach entails, and how it will be implemented within any respective study.

Furthermore, this study intends to fill the gap in identifying teacher training needs. More specifically, the benefits that arise from this study provide a basis for motivation (Shoukat et al., 2024). However, the challenges provide an understanding of how to effectively design a blended

learning approach (Alvarez, Jr., 2020). This study highlights challenges that need consideration, such as resources (i.e., costs, lack of adequate resources, etc.), technical challenges (i.e., network challenges, loadshedding, etc.), training needs (i.e., digital literacy, inadequate teacher training, time management, etc.), student commitment (lack of engagement, decreased motivation, failure to focus, plagiarism, etc.), and acknowledgement of the resistance towards the implementation of a blended learning approach. As noted by Mewborn and Huberty (2004) and Gumbo (2020), teacher training programmes often fail to meet professional developmental goals. More specifically, Gumbo (2020) highlighted the need for Technology Education content and pedagogical training needs. Acknowledging such challenges before the implementation of blended learning in Technology Education allows for the mitigation of it, and therefore the ability to set realistic expectations when implementing a blended learning approach in such a practical-based course.

The responses highlighted various blended learning approaches that could be employed in Technology Education courses, such as (i) flipped classrooms, (ii) lab rotation model, or (iii) HyFlex learning. Based on the overall responses from preservice teachers regarding their preferred approach for the learning domains within Technology Education, it was suggested that theoretical classes be presented online and supplemented with the application of knowledge during face-to-face drawing and practical classes.

Limitations

This study had several limitations, which included a relatively small sample size that is limited to one HEI. This may affect the overall generalisability of the findings. Future research should consider larger samples to validate the results of this study. Secondly, the study relied on self-

reported data from preservice teachers, which may be subject to response biases. Triangulating these findings with observational data could provide a more comprehensive understanding of the impact of blended learning. Lastly, the study focused on preservice teachers in Technology Education, and the findings may not be applicable to other STEM courses or other disciplines. It is recommended that future studies explore the perceptions and experiences of preservice teachers in different subject areas to provide a broader perspective on blended learning.

Conclusion and recommendations

This study reveals that Technology Education preservice teachers have a positive perception of blended learning, recognising its usefulness and ease of use. To enhance the effectiveness of blended learning, it is recommended that HEI provide comprehensive training for both in-service and preservice teachers, develop support systems, and ensure access to necessary technological resources. Future research should explore the long-term impact of blended learning on student outcomes in practical-based courses. In addition, these findings suggest that Technology Education preservice teachers consider the implementation of a blended learning approach as recommendable and essential for the contemporary changes in the education sphere. Moreover, the study highlights the possible implementation of such an approach in Technology Education, a practical-based course. The study applied the TAM as theoretical framework. From the results, most participants understood the term blended learning and could identify the possible benefits and challenges. This indicates that participants could identify the usefulness of the blended learning approach. Furthermore, from the responses, participants suggested a possible blended learning model whereby theory classes could be presented online, and drawing and practical classes could be presented face-to-face.

The findings further identified the perceived ease of use by indicating that online and face-to-face classes could complement each other through (i) clarification through collaboration, (ii) improved learning outcomes, (iii) flexibility and convenience, and (iv) improving research skills and technological literacy. The most frequently used applications for such an approach would be emails, the LMS, and WhatsApp. Lastly, regarding attitude towards using, findings indicate that participants were able to identify how they could assess personal progress and performance, maintain motivation and interest, manage time and workload, and gain the necessary technological knowledge and skills. The study concluded by noting that the majority of participants were excited about the possibility of the implementation of blended learning in a Technology Education course. The study therefore recommends the application of the suggested approach in a Technology Education course, or, likewise, any STEM-based course.

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ARTICLE 2: PROFILING THE ENGAGEMENT PATTERNS OF PRESERVICE TEACHING IN A BLENDED LEARNING TECHNOLOGY EDUCATION CLASS AT A SOUTH AFRICAN INSTITUTION

Introduction

This article was prepared using the guidelines for the Perspectives in Education (PiE) journal (cf. Appendix J). It addresses the second research question which ask, “How are preservice teachers engaged in blended learning Technology Education courses in South Africa?”. A qualitative research methodology was implemented whereby a total of 193 purposefully selected third-year preservice teachers engaged in a blended learning approach over a period of 6 weeks. These participants submitted individual and group project portfolios. Furthermore, the Community of Inquiry (CoI) framework was used as the underlying theoretical framework. From the results, a three-phase blended learning approach is suggested.

Profiling the engagement patterns of preservice teaching in a blended learning Technology Education class at a South African institution

Abstract. Blended learning combines online and face-to-face teaching and learning activities. The approach has been widely studied, but very little has been reported on the engagement of preservice teachers in blended learning within STEM courses. More specifically, literature on the implementation of a blended learning approach in Technology Education is very scarce. A cohort of 193 third-year preservice teachers were selected to participate in this study. These participants were purposefully selected to respond to the research question: How are preservice teachers engaged in a blended learning Technology Education course in South Africa? Data were collected through individual- and group-portfolio submissions over a period of six weeks. The Community of Inquiry (CoI) framework underpinned this empirical study. Grounded in three interdependent elements, namely teaching, cognitive and social presences, the researchers analysed the implementation of a suggested three-phase blended learning approach within the three interdependent elements. The findings make room for suggestions on how a blended learning approach can be effectively implemented in a Technology Education course. In addition, the paper reports on an extension of the second phase that emerged from the findings, which provides a conceptual framework on how the blended learning approach can be implemented in the design process. Therefore, a recommendation is made for a blended learning model that can be implemented in Technology Education.

Keywords: Blended learning, higher education institutions, preservice teachers, Technology Education

Introduction

Technology Education aims to develop technological literacy and prepare South African learners with the knowledge and skills needed in the 21st century (South Africa. Department of Basic Education [DBE], 2011). The subject covers a wide variety of fundamental topics, whereby theoretical knowledge must be applied practically. As such, this practical application and active learning means that Technology Education must be taught differently from other subjects (Gumbo, 2020; Mulaudzi, Du Toit & Golightly, 2023). This requires effective teacher training strategies to ensure that Technology Education and, therefore, the learners and preservice

teachers are prepared to keep up with contemporary society. However, as noted by Pudi (2007), Mapotse (2017) and Gumbo (2020), there is a critical gap in such teacher training programmes, with Technology Education in-service and preservice teachers facing challenges in their pedagogy and didactics. This could result in significant negative effects on achieving learning outcomes and overall quality education. There is therefore a need for teacher training programmes to review their content to ensure that they are kept up to date with the latest advancements, such as blended learning.

Within higher education institutions (HEI), the COVID-19 pandemic forced a move from face-to-face teaching and learning to online/blended learning (Faustino & Kaur, 2021; Lestari et al., 2021). Many protocols were implemented to manage the spread of the virus. As a new norm is entered, whereby normal community life continues with stricter health measures, face-to-face teaching and learning activities resume. However, the potential impact of online and blended learning approaches is evident. It therefore becomes imperative that Technology Education preservice teachers' experiences are prioritised to ensure they are well-prepared for the evolving educational landscape.

Numerous studies highlight how blended leaning can be implemented in Science, Technology, Engineering, and Mathematics (STEM) education (Candido et al., 2023; Puspitasari, Herlina & Suyatna, 2020; Rachmawati, Setyaningrum & Retnawati, 2019; Supriyadi et al., 2023). However, few studies focus on Technology Education, more specifically the design process, and blended learning (Mulaudzi et al., 2023). In addition, the voices and experiences of students are somewhat absent (Flavian & Kass, 2015; Mulaudzi et al., 2023). By reporting on preservice teachers' engagement in blended learning in a Technology Education class, the researchers aim to fill the gap in the literature by exploring preservice teachers' engagement in a blended learning approach implemented in Technology Education. More specifically, the study aimed to report on preservice teachers' engagement in the design process in a blended mode.

Theoretical framework

The Community of Inquiry (CoI) framework, which underpinned this study, was developed by Garrison, Anderson, and Archer in 2000 (Garrison & Archer, 2000). The framework combines digital online discussions, resources, and development with traditional face-to-face learning (Mielikäinen & Viippola, 2023). Three interdependent elements ground the theory, namely the teaching, cognitive, and social presences (Garrison & Archer, 2000). These elements establish

the procedures for critical thinking and inquiry, and the collaborative construction of shared, personal, and meaningful understanding (Mielikäinen & Viippola, 2023). The researchers found this theory relevant in its aim to report on preservice teachers' engagement in a blended learning approach in Technology Education. Figure 1 provides a graphical representation of the three interdependent elements.

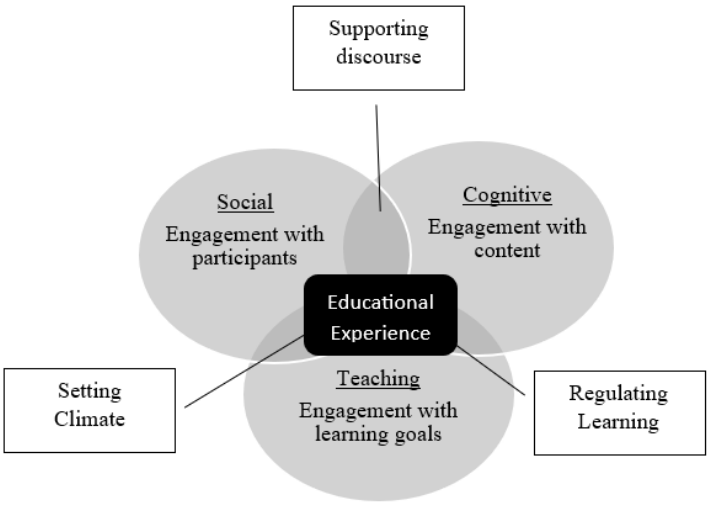


Figure 1: Elements of an Educational Experience (Adapted from Garrison et al. [2000:87])

The teaching presence refers to "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" (Anderson et al., 2001:5). In this study, *teaching presence* refers to the virtual theory class presented to the participating preservice teachers, as outlined in Phase 1 of Figure 3. The class was recorded, and slides were made available for participants to refer to. The cognitive presence refers to the ability of preservice teachers to construct and confirm meaning through their application of knowledge and engagement with others (Garrison & Archer, 2000). The study made use of both individual and group activities within the project. It is the intention that preservice teachers would develop their foundational knowledge for the project by completing the individual portfolio. The individual portfolio further encouraged the participants to consult other resources, including individuals who may provide expertise on the subject. Further details are outlined in Phases 2 and 3 of Figure 3. Finally, the social presence refers to preservice teachers' engagement with others, in which the individual will feel like they are part of a community (Arbaugh et al., 2008). Thus, following the submission of the individual portfolio, participants formed groups

to complete the project by selecting the best-suited design to make. The groups presented their project as part of Phase 3 (Figure 3).

Literature review

Blended learning in Technology Education

Blended learning is the combination of online and face-to-face teaching and learning. The approach offers many benefits, such as increased collaboration and engagement, enhanced research skills, flexibility, increased motivation, reduction in traditional face-to-face class attendance, increased higher cognitive thinking skills and increased active learning (Chan, 2019; Ketsman, 2022; McGuinness & Fulton, 2019). However, the approach also presents challenges, such as a lack of resources, increased workload, technical challenges, and poor preparation (Aidoo et al., 2022).

To contextualise this study, Technology Education should be explained. Technology Education, aimed at preparing students for life and employment (Mulaudzi et al., 2023), is recognised as a practical-based course. In South Africa, Technology Education was introduced to develop a technologically literate society within the modern world (South Africa. DBE, 2011). The DBE (South Africa, 2011:8) describes Technology Education as "[t]he use of knowledge, skills, values, and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration". The subject aims to stimulate innovation, creativity, design skills and critical thinking skills. In addition, time management, resources management, collaboration and teamwork skills are also developed (South Africa. DBE, 2011). The discipline focuses on three core domains, namely theory, drawing and practical, for the enhancement of technological literacy. More specifically, technological knowledge, processes and skills are applied using the design process.

However, literature reports that STEM education is primarily focused on the improvement of science and mathematical literacy, with very little attention given to technological and engineering literacy (Kelley & Knowles, 2016; Mapotse, 2017; Pappa, Georgiou & Pittich, 2024). As further noted by Kelley and Knowles (2016), the "T" in STEM education is often associated with educational technologies, which are used to enhance the learning experience, rather than the discipline, which consists of its own body of knowledge, practices and skills. This is further supported by Mapotse (2017) and Pappa et al. (2024), who highlight that there are also various descriptions and definitions ascribed to Technology, which exacerbates the need for a clear and

distinct body of knowledge. This complexity in defining Technology is further reflected in the various modes in which blended learning can be implemented, for example, the flex model, the flipped classroom, HyFlex learning, station rotation, lab rotation, and so forth (Bryan & Volchenkova, 2016; Faustino & Kaur, 2021; Krismadinata et al., 2020). However, as noted by Gumbo (2020), Mapotse (2017) and Mulaudzi et al. (2023), improving skills and competencies, such as keeping up to date with modern technologies, aligns with professional development. These authors contest that there is a need to provide students with opportunities to be actively involved in their learning and for them to have more purposeful training needs. More specifically, as noted by Mulaudzi et al. (2023), the implementation of hybrid learning in subjects such as Technology Education has not been thoroughly reported on. This study intends to contribute towards closing this literature gap in Technology Education. More specifically, the study intends to contribute towards literature on the implementation of blended learning in the design process within a teacher training programme.

The design process

The design process, also known as the technological process, is often referred to as the backbone of the subject. It can be described as a sophisticated and systematic thinking process that involves several steps (Hynes, 2010; South Africa. DBE, 2011). It should be used in designing and delivering technological learning aims (South Africa. DBE, 2011). The initial implementation requires that a problem be introduced; thereafter, the user will apply their technological knowledge and skills to ensure that the problem is resolved. As noted in the Curriculum and Assessment Policy Statement (CAPS) for technology, the key element to teach when focusing on the design process is the ability of the user to design (South Africa. DBE, 2011). Figure 2 provides a graphical representation of the design process as adapted from the CAPS for technology (South Africa. DBE, 2011) and illustrates the relationship between each step.

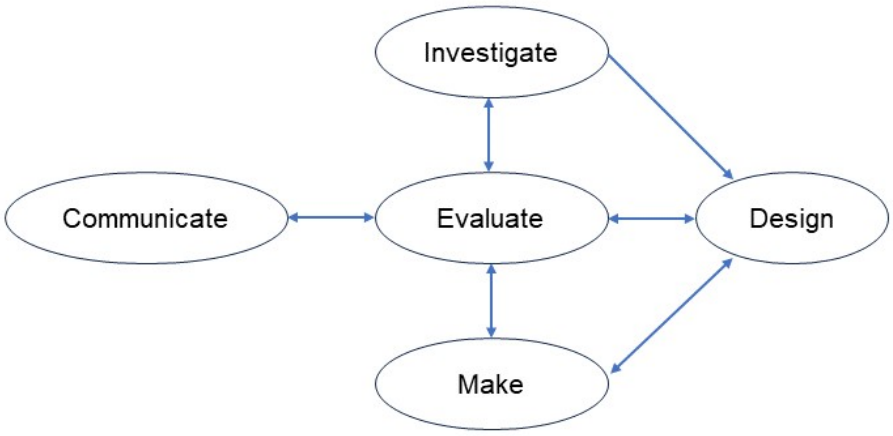


Figure 2: The design process in Technology Education (Adapted from DBE [South Africa, 2011:10])

The design process is not linear, but rather a cyclical process with a fixed sequence that is often rooted in evaluation (South Africa. DBE, 2011). As the user engages with the problem at each step, evaluation will determine whether the user can progress to the next step. The practical tasks should therefore be structured according to the sequence of the steps, more specifically, investigate, design, make, evaluate, and communicate. The practical task(s) may also focus on one or more aspects of the design process and not necessarily the entire process (South Africa. DBE, 2011).

Methodology

This study adopted a pragmatic paradigm to provide insight into preservice teachers' engagement in a blended learning Technology Education class. The application of a pragmatic paradigm in this research aligns with the views of Badley (2003:296), who explains that "pragmatists see inquiry not as discovering what is really out there but as offering more or less useful descriptions to meet our particular needs and purposes". Furthermore, a qualitative research methodology was employed. Preservice teachers were purposefully selected to respond to the research question: How are preservice teachers engaged in blended learning Technology Education courses in South Africa? A total of 193 third-year Technology Education students in a teacher training programme who were engaged in a blended learning approach participated in the study over six weeks.

Their participation was linked to a conceptual framework recommended in a paper by [omitted reference]. The framework is outlined in a three-phase blended learning approach as depicted in Figure 3.

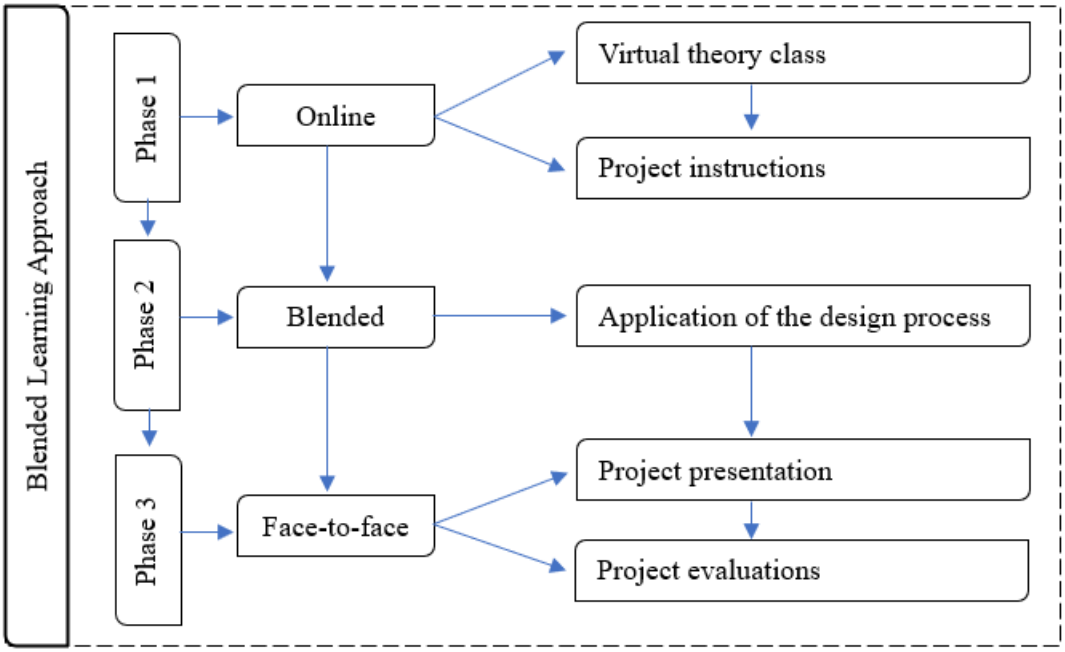


Figure 3: Technology Education blended learning model

Phase 1 outlines the online teaching and learning activities in which preservice teachers engaged. This includes attending virtual classes in which the theory was covered, in addition to the project instructions discussed. In Phase 2, the preservice teachers engaged in a blended mode, whereby they applied the design process. The preservice teachers submitted individual and group project portfolios sequentially as part of the application of the design process. Finally, in Phase 3, the preservice teachers engaged in face-to-face classes, in which they presented their project and were evaluated. The findings from the Technology Education blended learning model presented in Figure 3 are discussed in the next section.

Findings

This section reports on how participants engaged in a blended learning approach in a Technology Education course. By doing so, the researchers report on how a blended learning approach can be implemented, specifically related to the design process. Thus, the participating

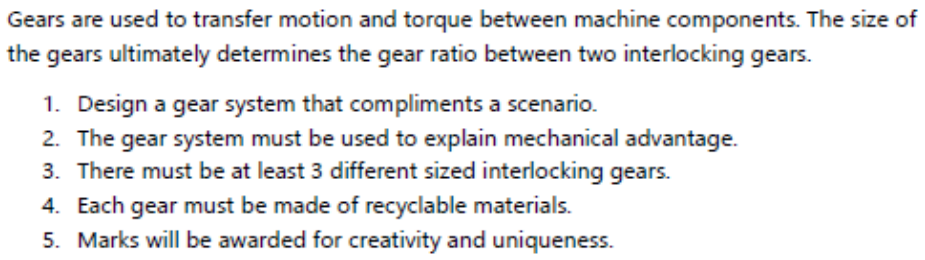
Technology Education preservice teachers' engagement in a blended learning approach is outlined as detailed in the conceptual framework model depicted in Figure 3 above.

Phase 1

This phase highlights the teaching presence element. More specifically, it refers to the teaching component such as virtual classes, or what was taught and how it was taught. The theoretical classes were presented online using traditional teaching methodologies. Within the class session, theoretical content knowledge was covered which related to the practical project. More specifically, the content covered the following learning outcomes:

1. Definition of gears
2. Purpose of gears
3. Types of gears
4. Mechanical advantage and gear ratios

The project instructions were also provided. Participants were encouraged to ask any clarifying questions. Figure 4 outlines the project instructions.


Gears are used to transfer motion and torque between machine components. The size of the gears ultimately determines the gear ratio between two interlocking gears.

1. Design a gear system that compliments a scenario.
2. The gear system must be used to explain mechanical advantage.
3. There must be at least 3 different sized interlocking gears.
4. Each gear must be made of recyclable materials.
5. Marks will be awarded for creativity and uniqueness.

Figure 4: Project instructions

Furthermore, the session was recorded, allowing the participating preservice teachers to refer to the content as needed. Statistics from Blackboard indicate that 153 of the 193 registered and active preservice teachers joined the virtual theory class. The graphs below provide a visual indication of how often the recording (Figure 5) and slides (Figure 6) were accessed from when the virtual theory class was presented (i.e., 15 August 2022) until the due date of the project (i.e., 24 September 2022). It should be noted that the learning management system reports on the number of times the users accessed the recording link and not the number of users who accessed the link.

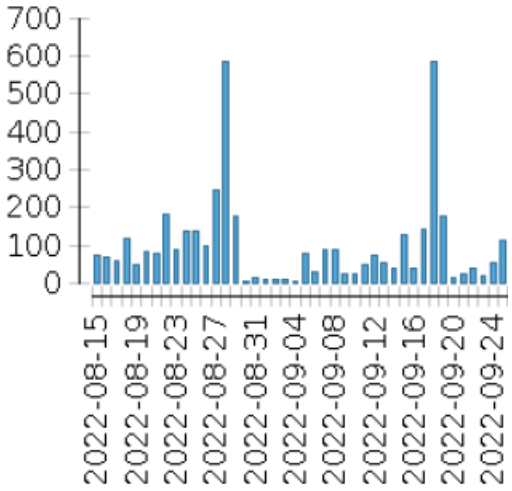


Figure 5: Access frequency of the virtual theory class recording

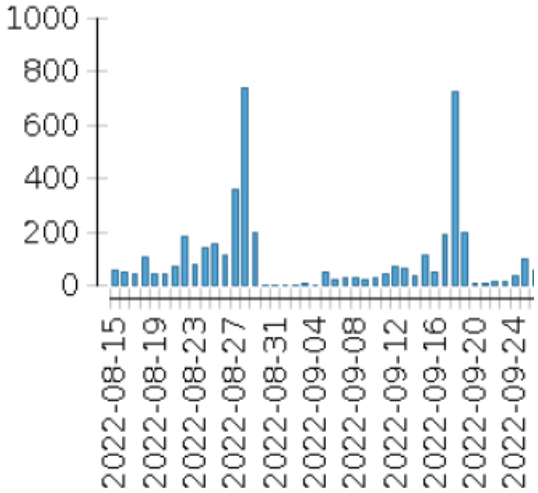


Figure 6: Access frequency of the virtual theory class slides

The information provided in Figures 5 and 6 indicates that the participants accessed the recording and slides frequently. Nonetheless, it was noted that only 79% of the participants attended the virtual class. These statistics could indicate that the remaining 21% of participants were catching up on the class session. The statistics could also indicate that participants referred to the recording and slides to refresh their knowledge for the practical project. The high numbers and frequency with which the recording was accessed could indicate that the content covered in the teaching presence was sufficient for participants to understand and achieve the learning outcomes. The session also provided directives for the cognitive and social presences. It is

recommended and encouraged that when such an approach is replicated, a recording is made available to users.

Phase 2

This phase responds to the cognitive and social presences. More specifically, it consisted of two subsequent submissions of an individual portfolio submission, and then a group portfolio submission and group project submission. As noted, the cognitive and social presences refer to the ability of preservice teachers to construct and confirm meaning through their application of knowledge and their engagement with others. As preservice teachers were only given the theory, it is required that they effectively and practically apply the knowledge, skills and resources learnt by engaging in the design process to complete the practical project. This is specifically referenced to the cognitive element. Participants were asked to investigate and design a gear system individually to ensure that they engaged in and could apply their content knowledge (cognitive presence). Thereafter, they would divide into groups (social presence) and choose the best scenario and design that they then would make and communicate/present to the class. The participants engaged in the design process as follows.

Investigate

According to the CAPS for technology (South Africa. DBE, 2011), this step involves investigating the context and need. It involves exploring values and attitudes and developing informed opinions. Furthermore, the investigation process involves the evaluation of existing products to determine the product's fitness for purpose in response to the identified problem. As per the instruction, the participants were asked to design a gear system that complements a scenario. They were encouraged to create scenarios that they could share with their learners one day. Among the answers were the following:

P91: *My mom has accidentally snapped the rope that we used to lift a 50-litre bucket from a well, so we need a new stronger material and since she is getting older, she needs to put less effort when pulling the water bucket from the well, so she needs an easier system to help her pull the water.*

P811: *I want to improve the gear system and the movement of a train. Electric trains tend to move faster and cannot stop when they are not in their stations even if it is for emergency*

purposes, so with this gear, I want to improve the movement of trains so that they move a bit slower and be able to stop anywhere at any time.

P141: *My grandfather has a farm and there's a scarcity of water, of which he cannot produce as much as he wants, so he decided to buy a windmill, but the windmill cannot work on its own because the wind speed is not high. He then decided to buy a gear system. Therefore, this gear system is used to increase the rotational speed of the windmill so that the water can come out.*

As the investigation was part of the initial step, the participants were asked if they were familiar with the content or if additional research was needed. Many of the participants indicated that they consulted other sources to assist them in their investigation. These included YouTube videos, TikTok videos, Pinterest, online articles, online textbooks, and online DIY projects. Only one participant indicated that they consulted an engineering student face-to-face. This therefore indicates that the majority of the participants were proactive and self-directed. They took it upon themselves to engage and seek knowledge and content online. They were able to identify information sources to enhance their cognitive understanding. Therefore, online learning works best for the investigation step.

Design

As previously stated, the design step is acknowledged as the key element of the design process. The researchers agree and encourage that more attention be given to this step. Analysis of participants' design process portfolios indicates that some participants were able to clearly communicate their intent through graphical communication, as seen in the following images in Figure 7.

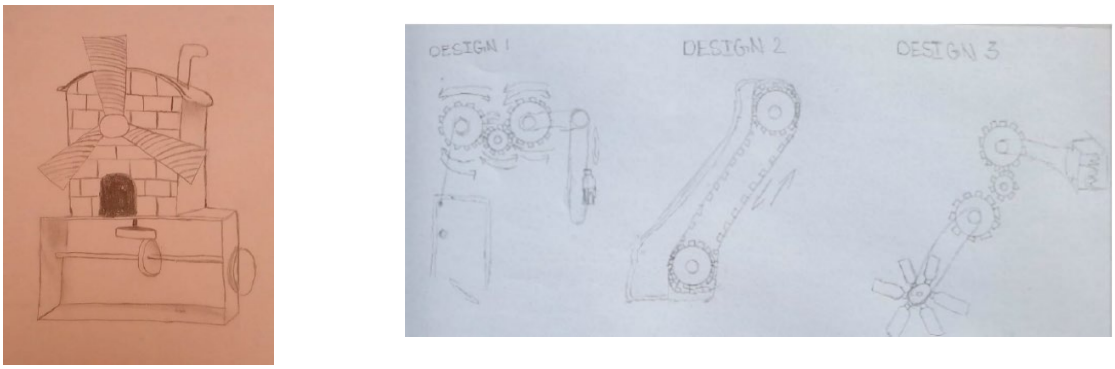


Figure 7: Participants' design process portfolios — clearly communicated intent

However, for other participants, there was a lack of effort and ability to graphically communicate their ideas, as shown in Figure 8. What the researchers found interesting was that the images below represent gears, indicating that participants understood the content. This could therefore indicate a lack of knowledge application. Also noted is that some participants lacked knowledge on how gear systems should work (i.e., teeth must mesh; three gears cannot be linked to each other at once or it will jam the system; different shapes and sizes require deeper thought to create a working gear system). This is evident in the Figure 8.

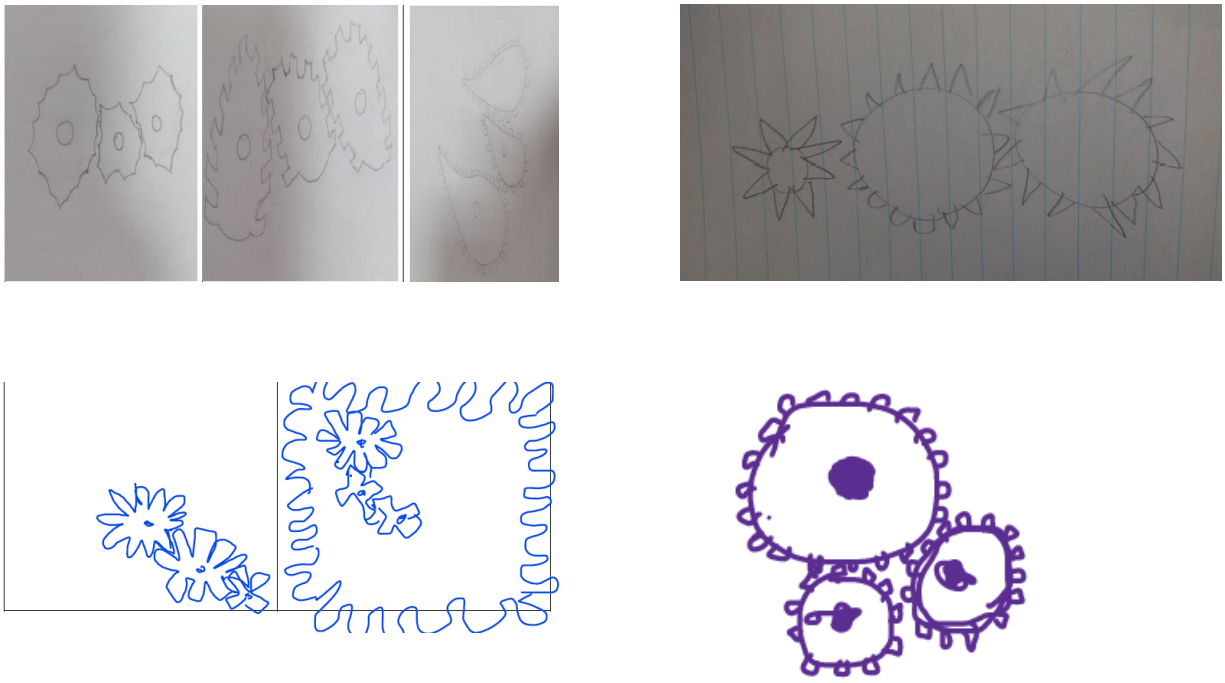


Figure 8: Participants' design process portfolios — poorly communicated intent

Although the design of the gear system required participants to draw, this step can be grouped into face-to-face and online, as participants indicated that they received inspiration for their designs from online sources. The cognitive presence therefore varied among participants in this step, indicating that their abilities to construct and confirm meaning varied.

Participants then divided themselves into groups. The following was highlighted when they were asked how they grouped themselves:

G1: *By places we stay at, since we want to be close to each other for us to work good.*

G4: *During the practical class, we chose ourselves based on the fact that we were seated at the same table.*

G7: *We are study partners since we are doing the same course.*

G28: *Via the WhatsApp group that was made available by the tutors.*

Other than groupings according to convenience and familiarity, instructors should conduct face-to-face sessions whereby individuals can meet and group themselves. Additionally, WhatsApp groups may also be created. Having implemented this step, participants were asked to discuss and choose the best design from group members. This highlights the social presence

both online and offline, the ability of the individual to participate in collaborative assignments that contribute towards learning. How they engage, share responsibilities, and overcome challenges is important.

Make

As participants began to make their gear system as a group, face-to-face interaction and participation were required. Participants could make their gear system in the technology lab or at another venue. Those who did not meet at the technology lab indicated that they met on the campus but at another venue. Only two groups indicated that they met at home. Figure 9 presents photographs of participants engaging and making their gear systems.

Figure 9: Participants engaging and making their gear systems

Furthermore, participants were asked what they most and least enjoyed about making the gear system. Table 1 indicates their commentary under the identified themes.

Table 1: Commentary regarding the making of the gear system

Positive	Negative
Creating	
P10: *Drawing the building background on the card box.* P24: *I enjoy that we were able to make a gear that looked difficult, which means we were most creative.* P31: *The thing that I enjoyed most was pasting using the glue gun; cutting the boxes and working with my team also was fun. And I got to meet new people whom I have never thought I would know, was also a great experience.*	P3: *We kept starting over because some of the materials were not strong enough, so we spent much time doing the system.* P161: *When our gear system was not functioning after several attempts without getting nowhere, I felt like giving up.* P166: *The only difficulties we come across in designing this gear, the teeth were not meshed and we tried to fix it several times; and also was the material, because some of material, such as glue, we were required to buy it, whereas we have no money.*
Group engagement and collaboration	
P4: *I enjoyed everything when we were doing gear system, as we were teaching each other about our scenario and we can make it happen in rural areas; also, we had to meet up now and then, so we can do gear system, and I enjoyed being with them.* P13: *I enjoyed the part of the research where everyone would compile their*	P2: *Late response from some of the group members when we were supposed to discuss some of the things via WhatsApp group chat and some of the members being late or not arriving at all when we were meeting.* P143: *The people are not easy to work with.*

own information needed to design the gear systems, which was enjoyable, since we all brought different information. I was a little bit shy, but I had support from my group members and that develops me to work great with other people. P26: *I enjoyed meeting new people and forming new relationships with people, who I was to bounce off ideas with and have the same views with.*	P159: *Time management. During our meetings, some arrived late, which made us procrastinate on our gear.*
Final product	
P46: *Seeing the load being lifted.* P67: *I also enjoyed the part of making the bucket because we struggled so much, and we had to compete whether who can make the best bucket.* P73: *I enjoyed working with other people, gaining knowledge, gaining skills, making something productive and learned how gears are made and how they actually work.*	P138: *Having to make another one because the initial design failed.* P147: *The project required a lot of time, and I had a lot of assignments already.* P177: *When the final product did not seem to work out, it was really frustrating and daunting.*

It should be noted that the majority of the responses show that participants enjoyed working in groups, collaborating, and sharing ideas. They indicated that they made new friends and enjoyed conversing. They commented on the support of the group members during challenging and frustrating times and noted the improvement in communication and teamwork skills. The majority of the challenges were related to a lack of time management, lack of planning and procrastination among group members. In addition, participants were asked if they

encountered any conflicts. The following are common challenges and the solutions to the challenges.

Problem: Group members coming late or not showing up for meetings.

Solution: Group members were reprimanded.

Problem: Inability to decide on a design.

Solution: Group members voted on the designs.

Problem: Procrastination.

Solution: Required the intervention of the group leader and discussion regarding the importance of completing the project.

Evaluate

The evaluation step required that participants evaluate their gear system by the instructions and rubric provided. In addition, they were asked how satisfied they were with their gear system on a scale from 1 (very dissatisfied) to 5 (very satisfied). Results indicate that 90% of the participants were either satisfied or very satisfied, 9.5% were neutral and 0.5% were very dissatisfied. Furthermore, participants were asked to reflect on how their gear system could be improved. Among the suggestions were to use stronger or better materials, decorate the final product and improve functionality. One group indicated that it could be improved by knowing more about gears and how they work, with another group indicating it can be done by doing more research. In addition, participants were asked how the project could be improved. Among the responses was that material should be provided instead of them having to use recyclable materials. In addition, the following commentary was noted:

P9: *This activity can be improved by increased the number of group members, and materials that are not recyclable should be used.*

P22: *Repeat the activity again, since we have experience from doing it initially and we can do more research on finding easier ways to do the activity.*

P35: *By giving students assignment on making gear systems more often, to improve their creativeness and critical thinking.*

P68: *By adding more questions that can challenge our knowledge skills.*

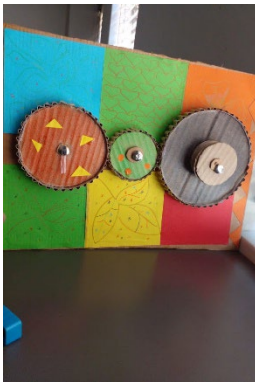
P74: *By emphasising the importance of group works and how they benefit us as students and also how communication is equally important.*

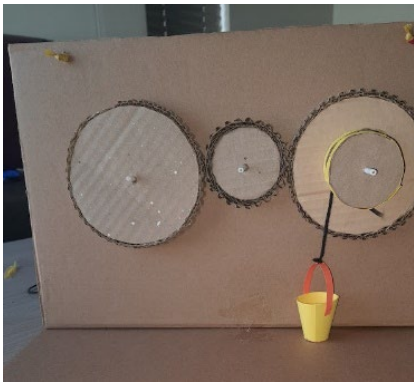
Communicate

According to the CAPS for technology (South Africa. DBE, 2011), communication is also seen as an integral part of the overall process. Participants indicated that WhatsApp was the only online communication tool used. In addition, they communicated face-to-face when meeting and making the gear system. The majority indicated that they met once or twice per week, while very few indicated meeting three or four times per week. Furthermore, participants indicated that they primarily engaged with peers or the instructor outside of their group members.

Phase 3

Phase 3 comprised of project presentations and project evaluations in a face-to-face setting. This phase responded to the social presence as groups were assessed on their presentation skills and demonstration of the functioning gear system. Furthermore, the gear systems were assessed with the use of a rubric on the functionality, creativity, uniqueness, and recyclable materials used. Below are photographs of the final gear systems designed, made, and presented by the participating Technology Education preservice teachers presented in Figure 10.





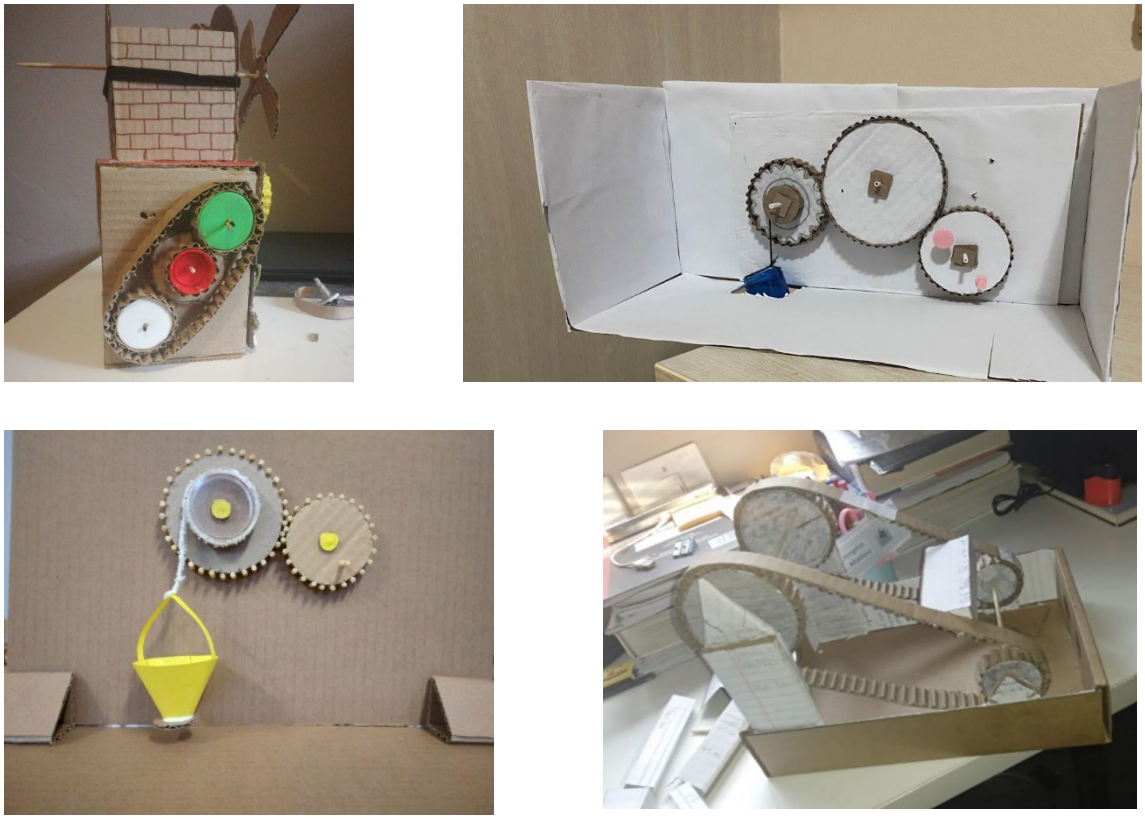


Figure 10: Final gear systems by participants

Discussion

The findings of this study provide valuable insights into the engagement of preservice teachers in a blended learning Technology Education course, highlighting the effectiveness of the three-phase approach in enhancing both theoretical understanding and practical application. In Phase 1, the teaching presence of the CoI framework was highlighted. More specifically, the phase consisted of (i) the content covered during the teaching and (ii) the outline of the project given to students. As such, instructors must ensure that content presented online is purposefully designed to ensure that learning outcomes are met (Alammary, Sheard & Carbone, 2014; Yang & Ghislandi, 2024). In addition, offering a recording reduces the need for physical class attendance, promotes active and student-centred learning, increases student autonomy, increases student research skills, and allows for flexible learning (Chan, 2019; Ketsman, 2022; McGuinness & Fulton, 2019).

In Phase 2, the cognitive and social presences are highlighted. Preservice teachers engaged in the design process, that is, investigating, designing, making, evaluating, and

communicating processes and systems (South Africa. DBE, 2011). Their engagement was in two parts. In Part 1, individual submission of a portfolio relating to investigation and design was made. Part 2 required group submission of a portfolio relating to the entire design process. However, the focus was primarily on making, evaluating and communicating. In doing so, Part 1 ensured that preservice teachers were able to apply the knowledge taught in the online class and not depend on the group. This ensured that students were able to effectively engage in collaborative learning (Barak, 2010; Mudrikah, Pitaloka & Setiyani, 2024). Furthermore, the findings from the investigative step of the design process highlighted several platforms and applications that preservice teachers consulted. This highlights the need to research and investigate platforms to be included in course design to serve as accessible digital resources in the curriculum to support self-directed learning and ensure comprehensive understanding. This will ensure that designs are created purposefully.

In Part 2, preservice teachers grouped themselves and were tasked with identifying and designing one project which they would then make. This provided preservice teachers with a basis whereby they were they could make contributions towards their learning goals and provide support (Barak, 2009). Their experiences varied from positive to negative across groups and individuals. However, the negative experiences provided the researchers with information on how to improve. The results highlight the need for regular contact to ensure that interest and performance are maintained. There is also a need for support from knowledgeable others who can assist in the development of multiple skills needed in the design process (Gumbo, 2020; Mulaudzi et al., 2023). Furthermore, the findings highlight a gap in the application of the design process in this study—the need to ensure that all materials are readily available for preservice teachers (Mawson, 2003). In addition, the challenges experienced could be minimised by providing regular feedback (Barak, 2009). Although the instructor was readily available, there is a need for more purposeful intervention to attain more critical feedback from preservice teachers. Finally, in Part 3, preservice teachers presented their project for evaluation purposes. As part of the outcomes linked to CAPS, communication is an integral part of the design process (South Africa. DBE, 2011). Letting preservice teachers present their projects ensured that they remained on par with the expected outcomes (Mawson, 2003).

Conclusion and recommendations

The study reports on preservice teachers' engagement in a blended learning Technology Education class in a South African HEI. From the findings, it is suggested that the three-phase

approach be adopted. Within Phase 1, theoretical knowledge should be presented virtually, and recordings and resources made available for users to download or refer to. The findings indicate that participating preservice teachers accessed the recordings and slides on numerous occasions throughout the 6 weeks. This could indicate that participants referred to content as a means to make up for missing class or as a reference when designing and making the project product. Phase 2 involved engagement with the design process. Based on the data analysed in response to the design process, the researchers recommend the following approach for Phase 2 of the blended learning approach. This is presented in Figure 11.

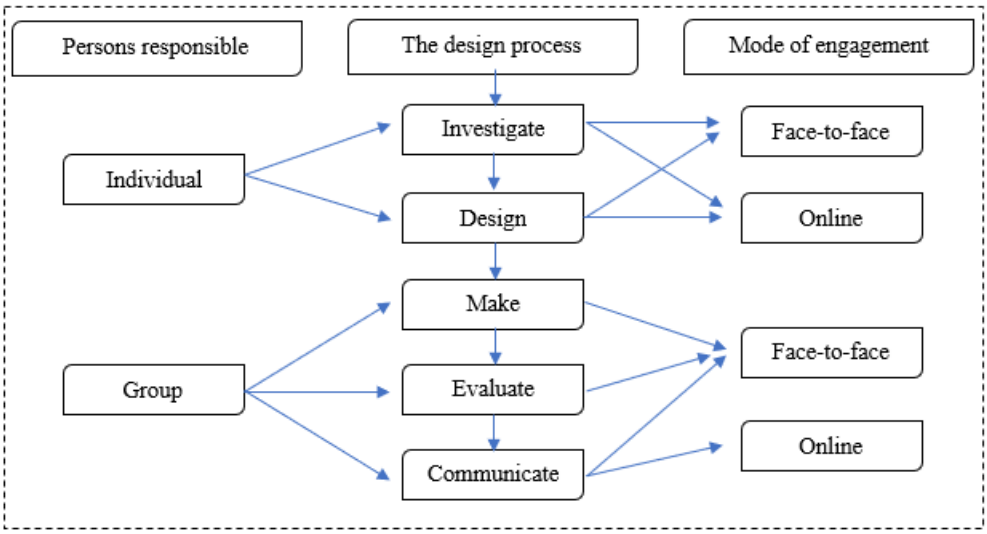


Figure 11: Implementation of the blended learning design process approach

It was found that participants engaged in a blended mode when engaging with the design process. It was also noted that the design step of the design process produced varied results in terms of the graphical communication of the gear system. It is recommended that if and when the approach is replicated in other studies, more attention be given to this step. Furthermore, Phase 3 consisted of project presentation and evaluation in the face-to-face classes. It is the view of the researchers that this study will encourage policymakers and instructors to review the benefits of integrating blended learning approaches in STEM education fields, such as Technology Education. However, the findings presented are limited to the engagement of preservice teachers in a blended learning approach implemented in Technology Education. The results, benefits and challenges associated with this approach are not reported on.

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ARTICLE 3: REPORTED PERCEPTIONS OF PRESERVICE TEACHERS ON BLENDED LEARNING IN A TECHNOLOGY EDUCATION CLASS

Introduction

This article was prepared using the guidelines for the Journal of Technology Education (JTE) (cf. Appendix K). It addresses the third research question which asks what are preservice teachers' perceived impacts of blended learning in Technology Education courses? A quantitative research methodology was implemented whereby a total of 93 purposefully selected third-year preservice teachers partook in a 30-item Likert-scale survey. The survey was distributed via Google Forms and analysed using Microsoft Excel and IBM SPSS. Furthermore, the Community of Inquiry (CoI) framework was used to evaluate their responses. The results indicate that, overall, the respondents had a positive response towards the items within the survey, and therefore towards the blended learning activity implemented in Technology Education.

Reported perceptions of preservice teachers on blended learning in a Technology Education class

Abstract

Technology Education, a course offered at higher education institutions (HEIs), is designed to prepare preservice teachers with the necessary skills and knowledge to teach it as a school subject. The course combines theoretical knowledge with practical application and intellectual development. Considering the increased application of blended learning approaches in HEIs, this quantitative study aimed to report on how Technology Education preservice teachers' experiences of a blended learning approach can be understood. The Community of Inquiry (CoI) framework underpinned the study. The framework is a widely accepted framework that represents blended learning environments. Three interdependent elements ground the CoI framework, namely the teaching, cognitive, and social presences. Data were collected using an adjusted version of the CoI survey and were analysed using Microsoft Excel and IBM SPSS. It was found that preservice teachers had positive perceptions of their involvement in the blended learning approach. From the analysis of data, it was found that the teaching presence element scored the highest, followed by the cognitive and social presence elements, respectively.

Keywords. Technology Education, blended learning, preservice teachers, teacher training

Introduction

Technology Education refers to the application of the knowledge, skills, resources, and processes associated with technology. It is one of the practical-based courses that is highlighted in STEM (science, technology, engineering, and mathematics) subjects. Scholars in the field of Technology Education have asserted that there is a need for teacher training programmes to develop strategies to enhance Technology teaching and learning processes to ensure the production of well-prepared Technology teachers (de Vries, 2000; Gumbo, 2016; Mapotse, 2017; Pappa, 2024; Seleke et al., 2018; Teis & Els, 2021). Mapotse (2017) further highlighted the need for teacher training programmes to ensure

that graduates “are well prepared to use new tools for learning” (p. 687). This is further supported by Pappa et al. (2024), who outlined the challenge of teacher training and professional development programmes that do not adequately, or effectively, enhance the subject. This highlights the need for preservice teachers to engage in teaching and learning approaches that replicate the importance of the subject and its context within the modern world. Although different instructional approaches can be implemented to teach practical-based courses, the blended learning approach in South African higher education institutions (HEIs) has only recently gained momentum (Castro, 2019; Sekome & Mokoele, 2022). This paper reports on the experiences of Technology Education preservice teachers regarding a blended learning approach.

Many studies have been conducted on the implementation of a blended learning approach in STEM subjects. Yilmaz and Malone (2020) investigated preservice teachers’ experiences of blended learning in a science methods course. The results indicate that a blended learning approach was considered “a pedagogy that makes use of the best attributes of each learning environment to promote the learning of science” (Yilmaz & Malone, 2020, p. 5). These authors reinforced the notion that blended learning is an effective approach for preservice teachers in the practical-based course. Furthermore, they highlighted that for a blended learning approach to be effective, planning is important in reducing preservice teachers’ reluctance to engage online. In addition, the teaching and learning approach should be prepared accordingly (Yilmaz & Malone, 2020). Moreover, Yilmaz and Malone (2020) noted that the communication and collaboration between the instructor and the student are influential in the academic performance of the student. Blended learning could therefore impact preservice teachers’ motivation and thus increase self-efficacy.

In a study conducted by Aidoo et al. (2022), the researchers investigated the benefits and challenges of implementing a blended learning approach in a STEM course for preservice teachers. It was found that preservice teachers had positive views on the blended learning approach. More specifically, preservice teachers reported that the approach encourages collaborative learning. As reported, preservice teachers’ interest, confidence, and learning outcomes were enhanced through collaboration (Aidoo et al., 2022). In addition, the connection between the instructor and preservice teachers improved because extra time space was available after moving content online (Aidoo et al., 2022). The study further identified challenges with the implementation of the blended learning approach, including the challenges arising from poor class preparation due to inadequate resources, increased workload, and technical challenges.

In their study, Romero and Angeles (2023) questioned whether a blended learning approach is successful in either raising or maintaining students' attitudes towards mathematics as a STEM subject. The study made use of two groups, a control group and an experimental group. It was found that the attitude of the control group, which had a traditional learning experience, had declined, specifically regarding their value, enjoyment, and motivation (Romero & Angeles, 2023). The experimental group, which experienced the blended learning approach, maintained a positive attitude towards mathematics.

Traditionally, practical-based courses have been associated with the "physicality of the classroom-based settings" (Best & MacGregor, 2017, p. 202), but we find ourselves in the midst of adapting educational practices in order to keep up with an ever-changing world. Pappa (2024) stated that "preservice teachers' familiarity with Technology Education depends largely on their elective choices" (p. 16), as Technology Education is usually paired in a broader elective of Natural Sciences and Technology (as taught in the Intermediate Phase). In another study, Pappa et al. (2024) emphasised that if a learner is not properly prepared for or exposed to Technology Education at a young age, it could cultivate resistance to/lack of confidence in engaging in a technologically driven society. This highlights the need to ensure that teacher training programmes prepare students to fully understand the context and rationale for Technology. Thus, the introduction of blended learning methodologies becomes ideal for supporting various learners and students, and for preparing them for a technology-centred world (Jarman, 2019). As stated by Clark et al. (2016), the teaching of technical subjects using traditional methods "is emerging as an ineffective and inferior method of instruction" (p. 2); therefore, there is a need to shift towards integrating face-to-face teaching with online learning activities using information and communication technologies.

Various other studies have also responded to the implementation of blended learning in STEM courses. Chang and Lee (2022) noted that STEM courses specifically are "harder to convert to the online mode" (p. 163), as the courses require both laboratories and hands-on experiences, which cannot be offered online. The authors noted that the purpose of STEM courses is to guide students towards developing critical thinking, problem-solving, and scientific thinking skills rather than to simply impart content knowledge (Chang & Lee, 2020). In a study conducted by Trang et al. (2021), it was found that the quality of the education was partly dependent on training and the need to have some or other background regarding both content knowledge and processes of the course. However, it was dependent on the need to understand the integration and implementation of the blended learning approach in the

course. Interestingly, Vo et al. (2017) reported that blended learning had a significantly higher impact within the STEM courses compared to that of other non-STEM disciplines. In addition, their study reported that greater learning performance is achieved in the implementation of blended learning approaches than in traditional learning within the STEM courses. Furthermore, according to Ketsman (2022), there is a need to explore how blended learning courses can support the growing curriculum needs of traditional teaching approaches at HEIs. More specifically, the author referred to the limited data available on the implementation of blended learning in teacher training programmes.

Problem Statement

Although blended learning has been implemented in HEIs from the late 20th century, it has become prominent only recently. The approach offers many benefits; however, very limited research is available on the implementation of blended learning in STEM fields. More specifically, very limited research is available on blended learning in Technology Education in teacher training programmes. This paper therefore intends to contribute to the literature by asking "What are preservice teachers' perceived impacts of blended learning in Technology Education courses?"

Theoretical Framework

Community of Inquiry (CoI) is the theoretical framework that underpinned this study. CoI was developed by Garrison, Anderson, and Archer in 2000. As noted by Pool, Reitsma, and van den Berg (2017:155), the CoI framework "is a valid and trustworthy instrument to measure the quality of online [and blended] learning environments". It emphasises critical thinking, knowledge construction, collaboration, and the formation of the community at the centre of the learning process (Garrison & Archer, 2000; Ketsman, 2022). CoI is grounded in three interdependent elements, namely teaching, cognitive, and social presences (Garrison & Archer, 2000; van der Merwe et al., 2015). Figure 1 presents a graphical representation of the CoI elements:

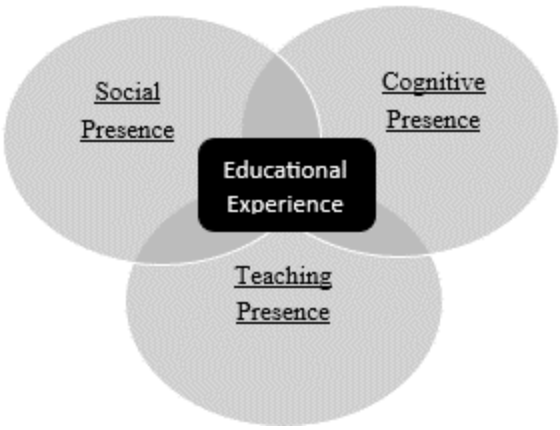

Figure 2: Elements of an educational experience (Adapted from Garrison et al. [2000, p. 87])

Understanding the relationship between the three CoI elements is essential to understanding the quality of the blended learning approach. Teaching presence refers to the design and facilitation of the course, and direct instruction (Arbaugh et al., 2008). Furthermore, the engagement with content and the achievement of the intended outcomes of the course are also noted. In this study, teaching presence refers to the different pedagogies implemented by the lecturer and experienced by preservice teachers; more specifically, it refers to their experiences in a blended learning class implemented to enhance technological literacy.

Cognitive presence refers to the extent to which [students] are able to construct and confirm meaning through sustained reflection and discourse (Garrison & Archer, 2000; van der Merwe et al., 2015). In this study, it requires preservice teachers to engage in meaningful reflection on content taught and learned within the Technology Education course and requires that they make meaningful connections to practical experiences. This is further linked to the knowledge and skill application in the design process.

Social presence, as highlighted by Arbaugh et al. (2008), is the ability of individuals to feel like they are part of a community. It also encompasses purposeful communication and the development of interpersonal relationships by allowing these individuals to project their personalities into the community (Arbaugh et al., 2008; Ketsman, 2022). Thus, in this study, social presence focuses on Technology Education preservice teachers' communication skills and the collaborative environment created in the blended learning approach. More specifically, it focuses on their willingness to participate in class (online and face-to face), their communication with peers during their engagement in the design process, and their engagement with the lecturer throughout the course. As this theoretical framework

addresses “student satisfaction and researching online teaching and learning” (van der Merwe et al., 2015, p. 12), it was found best suited for this study.

Literature Review

The purpose of a literature review section is to contextualise the study and provide literature that supports the research gap. The following sections outline Technology Education and its setting within South Africa, blended learning models and their application, and the implementation of a blended learning approach.

Technology Education

Technology Education, as a subject within South African schools, was introduced in 2005. Taught to Senior Phase learners, the subject aims to develop learners’ technological literacy, improve their creativity and problem-solving skills, and help them engage in critical thinking (Ankiewicz, 2020; Jones et al., 2016; South Africa. DBE, 2011). Technology Education has gained more and more attention in recent years, as it prepares learners for the future (South Africa. DBE, 2011). At a higher education level, Technology Education as a course is seen as an integrated, practical-based instructional course that is aimed to prepare students to become future teachers. As noted by Heymans (2007), the subject, and thus the course, “is an important element in the education of every student” and “occurs in both school and out of school” (p. 46). The course covers a broad spectrum of fundamental topics that prepare preservice teachers to be knowledgeable about technology. Apart from understanding these topics, a preservice teacher will need to be able to proficiently apply their knowledge by investigating, designing, developing, evaluating, and communicating processes and systems. This process is commonly referred to as the design process, a process that involves sophisticated thinking approaches and application of technical knowledge (Hynes, 2010). It is therefore necessary that preservice teachers understand and can apply their knowledge and skills when engaging with the design process.

With the increase in student enrolment in educational institutions, the development of these practical skills places a demand on instructors (e.g., one-on-one learning) (Alturise, 2020) and consequently on resources such as

tools, equipment, and materials. Thus, the teaching and learning strategies employed in Technology Education courses must evolve into more suitable methods to ensure that student learning is effective and that the needs of the profession are met. The exposure of Technology Education preservice teachers to blended learning, and their engagement in the approach, is necessary to understand the benefits firsthand.

The Blended Learning Model

Blended learning is a combination of online and face-to-face learning. Ketsman (2022) added that blended learning includes some or other element of student control; this can be with reference to the place of learning, the pace, the time, or the path. The terms digital learning, e-learning, hybrid learning, and virtual learning are often used interchangeably in reference to blended learning. According to Sommer and Ritzhaupt (2018), blended learning has gained popularity in HEIs. In South Africa, blended learning is advocated in HEIs (CUT, 2022; South Africa. DHET, 2013, 2017; UFS, 2019). While blended learning is the combination of varying two teaching and learning approaches, Sommer and Ritzhaupt (2018) indicated that it could be seen as an opportunity to improve learning. Likewise, Ketsman (2022) noted that future teachers must be exposed and prepared to teach in multiple learning environments using various instructional methods, such as blended learning.

The successful implementation of a blended learning approach can offer many benefits, including increased higher order thinking skills; reduction in physical class attendance; promotion of active, student-centred learning; increased collaborative learning; improved opportunities for individualised instruction; increased student autonomy and research skills; increased motivation; and flexible learning (Chan, 2019; Ketsman, 2022; McGuinness & Fulton, 2019). Ketsman (2022) noted that the implementation of a blended learning approach could be seen as less work for the student. This leads to a decrease in active engagement and learning. du Toit and Pool (2020) reported that the participants' perceptions were not in line with the course expectations in their study. In a study conducted by Clark et al. (2016), it was found that traditional teaching methods are found to be ineffective and inferior, highlighting the need to shift towards the integration of online learning. This stresses the need for intentional, well-planned, and effectively implemented blended learning approaches.

Implementation of the Blended Learning Approach

The Technology Education course at the selected HEI was previously taught face-to-face, whereby both theoretical and practical learning were conducted in a classroom setting. Activities were designed to develop preservice teachers' technical and design skills. The Covid-19 pandemic then brought about abrupt changes to the already fast-growing developments in teaching and learning imposed by technology (Alturise, 2020). As a result, the course was shifted to online. Recently, a blended learning approach was adopted for the Technology Education course. This approach was implemented to respond to challenges such as lack of space, lack of engagement, lack of resources, and resistance to technology. The blended learning approach implemented in this study required preservice teachers to engage in online classes and do their research in preparation for the practical activities. Online classes were presented on Blackboard Collaborate once a week and recordings were made available to preservice teachers. In addition, preservice teachers were requested to watch videos or, for those who preferred, research additional information that would contribute towards their understanding. Thereafter, the preservice teachers would engage in a practical activity that required them to apply their knowledge and understanding and improve their skills.

Method

The study was guided by the research question: What are preservice teachers' perceived impacts of blended learning in Technology Education courses? It adopted a positivist research paradigm in its aim to provide insight into the blended learning approach employed in Technology Education at a South African HEI. A quantitative research methodology was chosen as it allowed for the measurement and analysis of preservice teachers' experiences using a 30-item Likert-scale survey. The survey required preservice teachers to indicate their level of agreement or disagreement with statements divided into the CoI elements. Thus, a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) was used. As the CoI survey aims to measure the effectiveness of blended environments, this method was deemed most appropriate in capturing the experiences of the preservice teachers. The study focused on first-year undergraduate preservice teachers at a South African HEI. Participants were purposefully selected based on their engagement in a semester-long blended learning approach within Technology Education. A total of 93 preservice teachers participated in the survey, which was deemed sufficient to provide reliable data for analysis.

The survey was administrated online and distributed once at the end of their engagement. Once data were collected, it was processed using Microsoft Excel and IBM SPSS for descriptive and inferential statistics, respectively. The descriptive statistics, which included the mean scores and standard deviations, were calculated to provide an overall view of the findings and to summarise the responses. Thereafter IBM SPSS was used for inferential statistics to understand the data and draw meaningful conclusions. This analysis provided a clear picture of the Technology Education preservice teachers' experiences of the blended learning approach. To ensure validity and reliability, the original 34-item CoI survey was reduced to a 30-item survey to maintain focus. The CoI survey has been thoroughly validated in previous research as an effective tool to measure online and blended learning engagements (Kucuk & Richardson, 2019; Means & Neisler, 2023). The reliability of the survey was further confirmed with a Cronbach's alpha coefficient above 0.7, indicating strong internal reliability.

Ethical clearance was obtained from the relevant ethics committee [omitted data] and all ethical considerations followed. This included informed consent obtained from all respondents. Further measures were taken to ensure the confidentiality of the responses by anonymising data and storing survey results on a secure laptop with limited access.

Results and Discussion

The CoI survey was distributed to respondents after they had engaged in a blended learning approach. Table 1 outlines the CoI elements (i.e., teaching, cognitive, and social presence), the number of items within each presence, and the Cronbach alpha for each presence.

Table 1: Reliability Statistics for Community of Inquiry Elements

CoI element	Number of items	Source	Cronbach's alpha
Teaching presence	11	(Garrison, Anderson & Archer, 2000)	0.907
Cognitive presence	12		0.895
Social presence	7		0.778

The Cronbach alpha within this study ranges from 0.778 to 0.907, as indicated in Table 1. As Cronbach's alpha tests the reliability of a survey, or simply put, the degree to which the items in the survey measure the same construct (Forero, 2014), the findings of this study indicate a high degree of internal consistency between each CoI element. Furthermore, the findings for each of the CoI elements are discussed, that is, the teaching, cognitive, and social presence elements are tabled and discussed. Thereafter, the inferential statistics are presented and discussed.

Teaching Presence

The results of the teaching presence can provide insight into the effectiveness of the blended learning approach implemented in a Technology Education course. Moreover, the results can indicate the areas that lecturers will need to improve on to enhance preservice teachers' learning outcomes. Table 2 presents the results yielded through analysis of responses regarding the teaching presence element.

Table 2: Results for the teaching presence element

#	Statement	Total number of responses	Mean	SD
1	The lecturer clearly communicated important course topics and goals	92	4.55	0.70
2	The lecturer provided clear instructions on how to participate in course learning activities	93	4.56	0.68
3	The lecturer clearly communicated important due dates/time frames for learning activities	92	4.67	0.54
4	The lecturer was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn	92	4.28	0.80
5	The lecturer was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking	92	4.60	0.66
6	The lecturer helped keep the course participants on task in a way that helped me to learn	93	4.41	0.76
7	The lecturer encouraged course participants to explore new concepts in this course	90	4.38	0.71
8	The lecturer's actions reinforced the development of a sense of community among course participants	92	4.22	0.78

9	The lecturer helped to focus discussion on relevant issues in a way that helped me to learn	93	4.45	0.76
10	The lecturer provided feedback that helped me understand my strengths and weaknesses relative to the course's goals and objectives	90	4.27	0.86
11	The lecturer provided feedback in a timely fashion	92	4.21	0.86
	Average mean		4.42	

The teaching presence element received the highest mean score of 4.42 among the three elements. As stated by Kurek and Müller-Hartmann (2019), the teaching presence is vital in creating a positive atmosphere for learning. This suggests that the respondents had an overall positive experience in the blended learning approach. More specifically, this suggests that they perceived the instructor as effective in designing, facilitating, and directing the blended learning processes.

From the results, the item that scored the lowest average score of 4.21 within the teaching presence element was "the lecturer provided feedback in a timely manner". This indicates that respondents were not entirely satisfied with the instructor's responsiveness and availability during the implementation of the blended learning approach. This may have hindered their motivation to engage, as they did not receive feedback as quickly as they had hoped for. The second lowest scoring item within the teaching practice element was "the lecturer's actions reinforced the development of a sense of community among course participants", with an average of 4.22. This suggests that some respondents felt isolated and disconnected from fellow preservice teachers in the course, as the standard deviation for this item was 0.78. This also affects engagement and collaboration, as they did not really feel like part of a community or have a sense of belonging. The two lowest scores for the teaching presence element are assumed to have a direct connection to the social presence, which scored the lowest concerning the three presences.

The item that received the highest average score of 4.67 was "the lecturer clearly communicated important dates/timeframes for the learning activities". This indicates that the respondents appreciated the instructor's clarity and organisation of the course. This may also have helped respondents to manage their time. Thus, respondents were able to plan effectively and avoid procrastination. The item with the second highest average followed closely, namely "the lecturer was helpful in guiding the class towards understanding course topics in a way that helped me clarify

thinking", with a score of 4.60 on average. This suggests that respondents valued instructor feedback concerning their learning. It further suggests that respondents' understanding and application of course knowledge, skill, and resources were enhanced through the instructor's feedback. This could also relate to the cognitive presence, which scored the second highest among the three elements.

The researchers found it interesting that the lowest and the second highest scores related to feedback from the instructor. This suggests that although the respondents felt that feedback was not given promptly, they appreciated the feedback given and viewed it as constructive and motivational towards their development within the course (Yilmaz & Malone, 2020). In turn, this could lead to a positive perception about Technology Education in general.

Cognitive Presence

The cognitive presence refers to the ability to which the preservice teachers engage in reflection and critical thinking to construct their knowledge and understanding. Furthermore, the cognitive presence can provide insight into the quality of collaborative problem-solving. Table 3 indicates the results found through the analysis of responses regarding the cognitive presence element.

Table 3: Results for the cognitive presence element

#	Statement	Total number of responses	Mean	SD
1	Problems posed by fellow students increased my interest in course issues	92	4.13	0.80
2	Course activities piqued my curiosity	91	4.18	0.78
3	I felt motivated to explore additional content-related questions	93	4.16	0.65
4	I utilised a variety of information sources to explore problems posed in this course	92	3.99	0.90
5	Brainstorming and finding relevant information helped me resolve content-related questions	93	4.16	0.74
6	Online discussions are valuable in helping me appreciate different perspectives	93	4.18	0.91

7	Combining new information helped me answer questions raised in course activities	93	4.26	0.76
8	Learning activities helped me construct explanations/solutions	91	4.16	0.81
9	Reflection on course content and discussions helped me understand fundamental concepts in this class	92	4.23	0.81
10	I can describe ways to test and apply the knowledge created in this course	92	4.11	0.87
11	I developed solutions to course problems that can be applied in practice	92	3.96	0.95
12	I can apply the knowledge created in this course to my work or other non-class-related activities	92	4.36	0.76
	Average mean		4.16	

The cognitive presence element scored the second highest among the three elements, with a mean score of 4.16. This suggests that respondents were able to construct and engage meaningfully in the content through reflection and critical thinking. As stated by Siah et al. (2020), "[o]ne of the strengths of blended learning is that it uses different modes of teaching strategies to promote rigorous discussions and to ensure reflection-orientated learning" (p. 460). Thus, ensuring that the course is well planned is an important factor in the learning process. Factors such as a work scheme, announcements, weekly submissions for graphical communication, and clear expectations contributed to this learning process.

The item with the lowest score average of 3.96 within the cognitive presence element was "I developed solutions to course problems that can be applied in practice". This suggests that respondents did not find the practical-based activities relatable to real-life problems, and they could not relate it to practical situations. This poses a concern, as it could indicate that, for some, there was not a strong alignment of activities with technological outcomes. This therefore impacts the learning process and could result in poor learning experiences for preservice teachers if there is no intervention. This could also hinder the development of technological literacy among preservice teachers. This could also be resolved by allowing for alternative activities that provide more individualised instruction (Yilmaz & Malone, 2020). The second lowest score within the cognitive presence element was for the item "I utilised a variety of information sources to explore problems posed in this course", with a mean of 3.99. This suggests that the respondents did not engage in researching information or in active inquiry when doing activities. This may reduce the

depth of understanding in their problem-solving, critical thinking, and creative skills. This could be because of the unwilling attitudes to engage in online work because it is difficult or tedious (Yilmaz & Malone, 2020). Furthermore, Yilmaz and Malone (2020) stated that "online activities were not prepared considering the individual learning differences" (p. 16); there is thus a need to plan for more constructive engagement and feedback in blended learning courses.

The item that received the highest average score of 4.36 was "I can apply the knowledge created in this course to my other work and other non-related class activities". This suggests that respondents did engage in meaningful learning experiences whereby they could apply the knowledge, and skills learned in contexts outside of the class. This finding also suggests that there is incoherence between the knowledge, skills, and resources gained in theory classes and the practical-based activities. The item that scored the second highest average score of 4.26 was "combining new information helped me answer questions raised in course activities". This could indicate that respondents could scaffold information and form connections with prior knowledge. This suggests that the respondents were cognitively engaged in critical thinking and problem-solving skills within the course.

Social Presence

The results for the social presence element can provide insight into the participation and interaction of the respondents among each other. As interaction is critical for learning, the ability of the preservice teacher to project their identity in the class is crucial. Table 4 indicates the results yielded through analysis of responses regarding the social presence element.

Table 4: Results for the social presence element

#	Statement	Total number of responses	Mean	SD
1	Getting to know other course participants gave me a sense of belonging to the course	92	3.87	0.99
2	Online or web-based communication is an excellent platform for social interaction	92	3.87	1.19

3	I felt comfortable conversing through the online platforms	92	4.12	1.04
4	I felt comfortable participating in the course discussions	92	4.08	0.93
5	I felt comfortable interacting with other course participants	91	4.15	0.86
6	I felt comfortable disagreeing with other course participants, while still maintaining a sense of trust	92	3.82	1.10
7	Online discussions help me to develop a sense of collaboration	93	4.01	1.01
	Average mean		3.99	

The social presence element scored the lowest mean score of 3.99 among the three elements. This implies that respondents were not comfortable interacting online. This could be because the blended learning approach was implemented at a third-year level whereby the respondents were engaged primarily in face-to-face learning at schools, as in the study done by Aidoo et al. (2022). However, it could also be because of the unfamiliarity of the learning management system and preference towards traditional learning.

The item with the lowest average score within the social presence element of 3.82 was “I felt comfortable disagreeing with other course participants, while still maintaining a sense of trust”. This indicates that some respondents were reluctant to voice their opinions. In turn, it could suggest that they did not feel supported by their peers and/or their instructor. Two items scored the second lowest mean score of 3.87 within the social presence element. The first item, “online or web-based communication is an excellent platform for social interaction”, had a standard deviation score of 1.19. This indicates that the preference of respondents for face-to-face and online communication varied. However, because of the relatively low score within this presence element, the finding indicates that respondents did not prefer to engage in online platforms. The second item, “getting to know other course participants gave me a sense of belonging in the course”, had a standard deviation score of 0.99. This indicates that respondents could have felt isolated from the class. It also implies that they had limited online interactions with other preservice teachers in the course.

The item with the highest average score of 4.15 was “I felt comfortable interacting with other course participants”. This could confirm that the Technology Education course was designed to encourage preservice teachers

to engage with others to form learning communities. This could be through discussions in class or engaging with knowledgeable others for information. The item with the second highest average score of 4.12 was "I felt comfortable conversing through online platforms". This suggests that respondents knew how to engage in class. It is interesting to note that from what is reported from the lowest and highest mean scores, respondents knew how to engage online but preferred not to engage. This contradicts the finding of Aidoo et al. (2022), who indicated that a blended learning approach encourages collaborative learning. However, the activities presented in the Technology Education course in this study were individual, whereas those done in the study done by Aidoo et al. (2022) were mainly small group activities. This nonetheless confirms the suggestion by Yilmaz and Malone (2020), who stated that group activities could increase understanding and help preservice teachers prepare for classes.

Significance of the Findings

A deeper analysis was conducted to explore the statistical significance of the findings. This was done using the t-test, analysis of variance (ANOVA), and a post-hoc test, namely Tukey's Honestly Significant Difference (HSD) test. As described by Toprak (2019), a t-test refers to a statistical test used to compare the means of two groups to determine if they are significantly different from each other, while ANOVA assesses differences among three or more groups, and Tukey's test is a post-hoc analysis used after ANOVA to identify which specific groups differ significantly from each other.

The independent samples t-test revealed no statistically significant differences in teaching presence ($p=0.151$), cognitive presence ($p=0.299$), and social presence ($p=0.968$) between male and female respondents. Similarly, ANOVA results indicated no significant differences in teaching presence ($p=0.156$), cognitive presence ($p=0.144$), and social presence ($p=0.116$) across different age groups. These findings suggest that the blended learning approach is perceived similarly across genders and age groups, highlighting its broad applicability and inclusivity in Technology Education.

The absence of significant differences between genders and age groups in the perception of teaching, cognitive, and social presences suggests that the blended learning approach implemented in Technology Education is universally effective. This aligns with previous research by Adas and Shmais (2011) and Shantakumari and Sajith

(2015), who found similar results in a different educational context. The findings highlight the potential of blended learning to cater to diverse student populations, making it a versatile tool in Technology Education. Therefore, the findings suggest that the blended learning approach can confidently be implemented with the likelihood of it being effective across various demographic groups. Future research could explore other variables, such as cultural background or technological experience, to further understand the nuances of blended learning effectiveness.

Furthermore, the preservice teachers' eagerness to engage in blended learning activities was analysed by asking them to respond to the statement, "I look forward to engaging in blended learning activities". The hypotheses tested were that there are significant differences in teaching, cognitive, and social presences based on preservice teachers' eagerness. The results indicated significant differences in cognitive and social presences, as displayed in Table 5.

Table 5: One-way ANOVA: Eagerness to engage in blended learning activities

CoI Presence		Sum of squares	df	Mean square	F-value	p-value
Teaching presence	Between groups	2.605	4	0.651	2.362	0.059
	Within groups	24.266	88	0.276		
	Total	26.872	92			
Social presence	Between groups	9.212	4	2.303	6.462	<0.001
	Within groups	31.360	88	0.356		
	Total	40.572	92			
Cognitive presence	Between groups	5.290	4	1.322	5.158	<0.001
	Within groups	22.564	88	0.256		
	Total	27.854	92			

In general, a significance level of $p < 0.05$ is used to determine statistical significance. Although there was no statistically significant difference in teaching presence ($p=0.059$), the trend towards significance suggests potential underlying differences that could become significant with a larger sample size, different subjects, or different conditions, encouraging further studies. However, statistically significant differences were found for cognitive and social presences ($p<0.001$), indicating that students' experiences of these presences vary significantly based on their eagerness to engage in blended learning activities. This highlights the importance of these factors in educational settings, but more specifically, it highlights the need for transparency when implementing the blended learning

approach in various subjects. Furthermore, the significant differences in cognitive and social presences suggest that these aspects of the learning experience are influenced by students' attitudes and motivations. This aligns with previous research by Cao (2023), who found that a positive attitude towards blended learning approaches resulted in more meaningful learning experiences and deeper attainment of learning outcomes. In line with the findings of Vaughan (2014), this study recommends the design (and redesign) of the implementation of blended learning approaches "for active and collaborative learning experiences that enable students to take responsibility for their learning and to validate their understanding through discourse and debate with their peers" (p. 261).

In addition, preservice teachers were asked to respond to the topic of access to a stable and reliable internet connection. The initial findings for this survey item indicate that 37.6% of the preservice teachers always had access (Group 1), 37.6% had access most of the time (Group 2), and 15.1% sometimes had access to a stable and reliable internet connection (Group 3). Using one-way ANOVA and the post-hoc Tukey HSD test, the study sought to analyse the impact internet access had on teaching presence, social presence, and cognitive presence. The hypotheses tested were that there are significant differences in these presences based on internet access levels. The results for the one-way ANOVA: access to stable and reliable internet is shown in Table 6.

Table 6: One-way ANOVA: Access to stable and reliable internet

CoI Presence		Sum of squares	df	Mean square	F-value	p-value
Teaching presence	Between groups	2.754	2	1.377	5.138	0.008
	Within groups	24.118	90	0.268		
	Total	26.872	92			
Social presence	Between groups	4.615	2	2.307	5.775	0.004
	Within groups	35.957	90	0.400		
	Total	40.572	92			
Cognitive presence	Between groups	2.012	2	1.006	3.503	0.034
	Within groups	25.842	90	0.287		
	Total	27.854	92			

The ANOVA for the teaching presence indicated that there is a significant effect of the access to internet levels on preservice teachers' experiences of the teaching presence ($F(2, 90) = 5.138$, $p = 0.008$). This result suggests that preservice teachers' experiences of teaching presence significantly differ depending on their level of internet

access. For cognitive presence, the ANOVA also indicated a significant effect of the access to internet levels ($F(2, 90) = 3.503$, $p = 0.034$), suggesting that cognitive presence is significantly influenced by preservice teachers' internet access levels. Similarly, the ANOVA for social presence showed a significant effect of the access to internet levels ($F(2, 90) = 5.775$, $p = 0.004$). This suggests that preservice teachers' social presence in the blended learning environment varied significantly as well.

The results demonstrate that preservice teachers' levels of internet access significantly affected their experiences of teaching presence, cognitive presence, and social presence in a blended learning environment in Technology Education. Specifically, it was found that preservice teachers' who always have access to the internet tend to report higher levels across all three CoI elements compared to those who have less consistent internet access. These findings highlight the importance of reliable internet access in supporting effective blended learning experiences for preservice teachers. To further analyse the data, the study sought to identify which means were significantly different and estimate the magnitude of these differences using the post-hoc Tukey HSD test. The results are presented in Table 7.

Table 7: Tukey HSD test results

Tukey HSD					
Dependent variable	(I) Access variable	(J) Access variable	Mean difference (I-J)	Std. error	Sig.
Teaching presence	Group 1 – Always/All of the time	Group 2 – Most of the time	0.02965	0.11725	0.965
		Group 3 – Sometimes	0.49623	0.16370	0.009
	Group 2 – Most of the time	Group 1 – Always/All of the time	-0.02965	0.11725	0.965
		Group 3 – Sometimes	0.46658	0.15884	0.012
	Group 3 – Sometimes	Group 1 – Always/All of the time	-0.49623	0.16370	0.009
		Group 2 – Most of the time	-0.46658	0.15884	0.012
Social presence	Group 1 – Always/All of the time	Group 2 – Most of the time	0.01824	0.14316	0.991
		Group 3 – Sometimes	0.63265	0.19988	0.006
	Group 2 – Most of the time	Group 1 – Always/All of the time	-0.01824	0.14316	0.991
		Group 3 – Sometimes	0.61441	0.19395	0.006

	Group 3 – Sometimes	Group 1 – Always/All of the time	-0.63265	0.19988	0.006
		Group 2 – Most of the time	-0.61441	0.19395	0.006
Cognitive presence	Group 1 – Always/All of the time	Group 2 – Most of the time	0.06827	0.12137	0.840
		Group 3 – Sometimes	0.43994	0.16945	0.029
	Group 2 – Most of the time	Group 1 – Always/All of the time	-0.06827	0.12137	0.840
		Group 3 – Sometimes	0.37166	0.16442	0.067
	Group 3 – Sometimes	Group 1 – Always/All of the time	-0.43994	0.16945	0.029
		Group 2 – Most of the time	-0.37166	0.16442	0.067

The Tukey HSD test indicated significant differences in teaching presence between Group 1 (Always/All the time access to stable and reliable internet) and Group 3 (sometimes have access to stable and reliable internet) (mean difference = 0.4962, p = 0.009). There is also a significant difference between Group 2 (Most of the time have access to stable and reliable internet) and Group 3 (mean difference = 0.4666, p = 0.012). These results suggest that preservice teachers with constant stable and reliable internet access perceive a higher teaching presence compared to those with intermittent access. However, it should be noted that no significant difference was found between Group 1 and Group 2 (mean difference = 0.0297, p = 0.965), indicating that these preservice teachers had similar perceptions of teaching presence among the preservice teachers with constant and mostly reliable internet access.

For cognitive presence, a significant difference was found between Group 1 and Group 3 (mean difference = 0.4399, p = 0.029), indicating that preservice teachers with constant internet access perceive a higher cognitive presence compared to those with intermittent access. Like teaching presence, no significant differences were observed between Group 1 and Group 2 (mean difference = 0.0683, p = 0.840), but there was also no significant difference found between Group 2 and Group 3 (mean difference = 0.3717, p = 0.067). This suggests that while constant internet access significantly enhances cognitive presence compared to intermittent access, the difference between mostly reliable and intermittent access is not necessarily statistically significant.

Furthermore, significant differences were identified in social presence between Group 1 and Group 3 (mean difference = 0.6327, p = 0.006) and between Group 2 and Group 3 (mean difference = 0.6144, p = 0.006). These findings highlight that preservice teachers with constant stable and reliable internet access experience a higher social

presence in online learning environments compared to those with intermittent access. Like teaching and cognitive presences, no significant difference was found between Group 1 and Group 2 (mean difference = 0.0182, p = 0.991), suggesting that both groups perceived social presence similarly.

The results indicate that stable and reliable internet access is crucial for enhancing preservice teachers' perceptions of teaching, cognitive, and social presences in blended learning environments. Preservice teachers with constant or mostly reliable internet access reported significantly higher levels of teaching and social presences compared to those with intermittent access. Additionally, constant internet access significantly improves cognitive presence compared to intermittent access, underscoring the importance of reliable internet connectivity for effective online learning. The significant differences in teaching, cognitive, and social presences based on preservice teachers' levels of internet access suggest that reliable internet access is crucial for effective blended learning. Various studies report that stable and reliable internet significantly enhances blended learning experiences by enabling timely access to resources and attendance of virtual classes, facilitating efficient research, and promoting active participation in collaborative projects (Akmad & Abatayo, 2024; Prajveen et al., 2024). Conversely, unstable connectivity leads to delays, increased stress, hindered engagement, and diminished academic performance among students (Akmad & Abatayo, 2024; Ando et al., 2022; Geçer & Dag, 2012). The results further indicate that a stable and reliable internet connection should be prioritised to support preservice teachers and improve their learning experiences. This study suggests that future research could explore other factors that influence the effectiveness of blended learning, such as the quality of online resources and the level of technical support available to students.

Conclusion and Recommendations

The study aimed to explore the experiences of preservice teachers engaging in a blended learning approach within the context of Technology Education at the university level. The findings reveal that the overall response to the blended learning activities was positive, with all average means per survey item being 3.82 and above. This indicates that the respondents generally had a favourable perception of the blended learning approach implemented in their Technology Education courses. One of the significant findings of the study was the lack of statistically significant differences in teaching presence, cognitive presence, and social presence between male and female participants, as

well as among different age groups. This suggests that the blended learning approach is perceived similarly across genders and age groups, highlighting its broad applicability and inclusivity in Technology Education. Such inclusivity is crucial for ensuring that educational strategies are effective for diverse student populations.

Furthermore, the study examined the impact of preservice teachers' eagerness to engage in blended learning activities. Significant differences were found in cognitive and social presences based on the level of eagerness. This underscores the importance of fostering motivation and enthusiasm among students to enhance their overall engagement and experience in blended learning environments. Educators should consider strategies to boost students' eagerness to participate, as this can lead to more positive learning outcomes. It is suggested that clear guidelines and expectations be established and communicated when blended learning approaches are implemented. In addition, another critical aspect that was investigated is the role of internet access. The findings indicate that stable and reliable internet access significantly affects preservice teachers' experiences of teaching presence, cognitive presence, and social presence. Preservice teachers with constant or mostly reliable internet access reported higher levels across all three CoI elements compared to those with intermittent access. This highlights the necessity of reliable internet connectivity in supporting effective blended learning experiences. Educational institutions must prioritise providing stable internet access to ensure all students can fully benefit from blended learning. Using the post-hoc Tukey HSD test to further clarify the differences, the results confirmed a significant variation in teaching, cognitive, and social presences between groups with different levels of internet access. More specifically, preservice teachers with constant stable and reliable internet access perceived higher levels of these presences compared to those with intermittent access. This finding emphasises the need for consistent and reliable internet access to maximise the benefits of blended learning. As a blended learning approach offers numerous benefits and opportunities for teaching and learning activities in Technology Education, it can also pose significant challenges if not implemented carefully. These challenges can create biased learning opportunities, which could disadvantage certain groups if not taken into consideration.

In conclusion, this study suggests that blended learning approaches in Technology Education courses should be designed, implemented, and facilitated to ensure that theoretical knowledge is directly linked to authentic, practical activities. Ensuring that preservice teachers have access to stable and reliable internet is a critical component of this process. Furthermore, managing preservice teachers' expectations and providing regular, constructive feedback are

crucial for maintaining motivation and engagement. Blended learning approaches should be designed to encourage interaction among instructors and preservice teachers, fostering a collaborative and supportive learning environment. By engaging in a carefully implemented blended learning approach, the learning outcomes in technological education courses can help preservice teachers develop the skills and knowledge necessary to create a technologically literate society when they begin their teaching careers.

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SECTION C: CHAPTER 4
DISCUSSION OF KEY FINDINGS, CONCLUSION, AND RECOMMNEDATIONS

4.1 INTRODUCTION

This final section begins with a summary of how the study was conducted. Thereafter, the key findings of each article and the anticipated scholarly contribution are discussed. Finally, the study responds to the main research question which asks, “How do South African preservice teachers experience blended learning in a Technology Education class?”. The overall findings suggest a conceptual framework. It is important to note that the conceptual framework outlined in the recommendations is derived from the findings and designed by the researcher. It is the first study to identify a blended learning approach implemented in Technology Education; more specifically, in the design process of a teacher-training programme. It is thus helpful to capture this conceptual framework to enable other Sciences, Technology, Engineering, and Mathematics (STEM) teacher educators and higher education institutions (HEIs) to test or explore the use of the framework in their respective courses. The study then concludes with recommendations for future research and conclusions to the study.

4.2 SUMMARY OF THE FINDINGS AND SCHOLARLY CONTRIBUTION

The study aimed to explore preservice teachers' experiences of a blended learning approach implemented in Technology Education. Moreover, the study explored how preservice teachers perceive, understand, engage, and experience blended learning in Technology Education. This was done by the use of a document analysis, a survey, and open-ended interview questions designed to answer the main research question. That is, to answer how South African preservice teachers experience blended learning in a Technology Education class. The secondary research questions guided the researcher in terms of article development:

Secondary research questions:

1. How do Technology Education preservice teachers perceive and understand blended learning within a university context?

Preservice teachers respond to an open and close-ended interview questions regarding their familiarity with the blended learning approach; their understanding of the approach; the benefits and challenges that come with its implementation; how they propose its implementation; their preferences and engagement, and their anticipated excitement about the possibility of its implementation.

2. How are preservice teachers engaged in blended learning Technology Education courses in South Africa?

Preservice teachers' engagement in the design process, as part of the practical-based activity is discussed, and patterns identified. Their engagement was documented in an individual and a group portfolio which was submitted as part of their engagement in the design process. The researcher also proposed a blended learning model as outlined from the data collected.

3. What are preservice teachers' perceived impacts of blended learning in Technology Education courses?

Using the Community of Inquiry (CoI) survey, the researcher reported on preservice teachers' experiences in a blended learning approach implemented in Technology Education. More specifically, the teaching, cognitive, and social presence were discussed.

The Technology Acceptance Model and the Community of Inquiry framework were used as the underpinning theoretical frameworks for this study. Moreso, the Technology Acceptance Model was used as it responds to how users perceive technologies as useful, their perception of the ease of use, and their attitude towards using. Furthermore, Community of Inquiry Framework was used as it focused on blended learning.

Furthermore, it provided a holistic overview for understanding how three different elements interact and influence the learning experience for students: namely the teaching, cognitive, and social presence. The study employed a mixed-method research approach consisting of qualitative and quantitative data collection tools. More specifically, document analysis and open-ended interview questions formed the qualitative research tool, and a survey was the quantitative research tool. A multiple-case study design was used in this study, which consisted of two case study groups. More specifically, a 2022 group, participated in a predetermined blended learning approach in Technology Education, to answer research questions 2 and 3. This cohort had experience in a blended learning approach previously implemented in Technology Education in the first semester. The second group was a 2023 group, who participated in the blended learning open-ended interview questions and answered research question 1. This group had no prior engagement in a blended learning approach implemented in Technology Education.

The study commenced from three premises, to which the researcher sought to contribute insights:

1. Blended learning can be implemented in a variety of ways. However, traditional learning approaches are still favoured due to obstacles that are difficult to overcome (Hardman, 2005; Ma'arop & Embi, 2016; Sam & Soong, 2019; Wahab et al., 2016). Bazelais and Doleck (2018) note that traditional teaching approaches have often been criticized as being ineffective for the teaching of a STEM education course. Thus, obstacles to overcome include institutional, instructional, student, and technological challenges as discussed in chapter 2. The researcher thus highlighted these obstacles to encourage HEIs, teacher educators, and preservice teachers to engage in blended learning approaches to enhance digital literacy.

2. Blended learning offers benefits and challenges (Chan, 2019; Clark et al., 2016; Ma'arop & Embi, 2016; McGuinness & Fulton, 2019; Ndlovu et al., 2020; Joksimović et al., 2015; Viljoen & Van Schoor, 2015; Wahab et al., 2016; Wiebe et al., 2011) and the approach is mandated by many HEIs

(CUT, 2022; DHET, 2013; DHET, 2017; UFS, 2019; UKZN, 2018) and policies (DHET, 2013; DHET 2017). This said, little is known about the design and implementation of blended learning approaches in practical-based teacher-training programmes (Ketsman, 2022; Ma'arop & Embi, 2016; Mulaudzi, 2023; Platonova et al., 2022; Saterbak et al., 2014; Joksimović et al., 2015; van Schalkwyk, 2021). The researcher thus aims to contribute towards the implementation of blended learning approaches in Technology Education teacher-training programmes.

3. Finally, as a teacher educator and researcher, the researcher sought to confirm the blended learning approach that was implemented in the Technology Education course that they undertook. It is the intent to improve on and find the best practice for implementing blended learning in a STEM education course, to develop teachers who are technologically and digitally literate.

4.2.1 Article 1 Findings and Scholarly Contribution

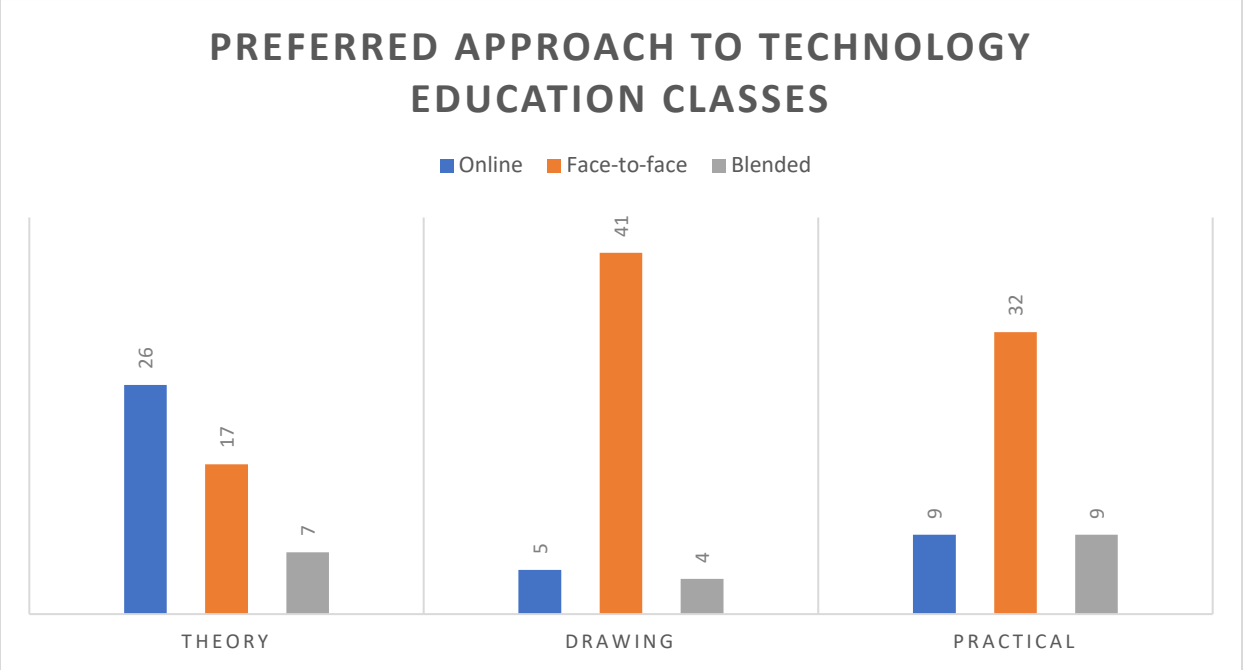
Article 1, titled "Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university", addresses the first research question; more specifically, the article provides insight into 50 preservice teachers' perceptions and understanding of blended learning in a university context. Below, a summary of the article findings are presented, and the anticipated scholarly contribution is outlined.

a) Article 1 Findings

The findings suggest that Technology Education preservice teachers consider the implementation of a blended learning approach as recommendable and essential for the contemporary changes in the education sphere. From the results, it was found that the majority of preservice teachers understood the term blended learning and could identify

the possible benefits and challenges as found in the literature (section 2.2). This indicates that participants could identify the usefulness of the blended learning approach. Moreover, the study highlights the possible implementation of such an approach in Technology Education, a practical-based course. The recommended approach, as highlighted below in Table 4.1, identified that theory should be presented online, drawings should be presented face-to-face, and practical classes should be presented face-to-face as well. The majority of responses further indicated that online classes should be conducted either once or twice a week; similarly, face-to-face classes should be conducted either once or twice a week per learning domain.

Table 4.1: Preferred Learning Approaches in Technology Education



Furthermore, the study further identifies that online and face-to-face classes could complement each other through (i) clarification through collaboration; (ii) improved learning outcomes; (iii) flexibility and convenience, and (iv) improved research skills and technological literacy. The most frequently used applications for such an approach would be emails, the LMS, and WhatsApp. Lastly, the findings indicate that preservice teachers were able to identify how they could:

1. Assess personal progress and performance

The findings suggest that preservice teachers would create assessments to test their knowledge; create weekly plans on what should be attained/understood; create study timetables; reflect on the course content; monitor summative assessment marks; redo assessments for improvement; communicate with lecturers and tutors often, and/or create rubrics.

2. Maintain motivation and interest

From the responses, preservice teachers indicated that their motivation and interest would be affected by the engagement with technologies; access to resources (positive responses towards having access to online resources, recordings, and assessments); ease of communication (ease of communication with peers and instructors); suitable learning environments (ability to learn from anywhere), and interest in learning through different learning approaches.

3. Manage time and workload

The findings indicated that the approach would save time as teachers would not need to prepare for face-to-face classes; they could simply log onto the LMS using their digital devices. A blended learning approach would assist them in managing their workload, as they would be able to access learning materials and recordings at a later stage. This would also allow them to refer to recordings multiple times to ensure their understanding.

4. Gain the necessary technological knowledge and skills

Amongst the responses, preservice teachers indicated that they would set clear goals; do self-assessments; ask the instructor; ensure that they attend classes; contact their peers and instructor when needed, and review course outcomes to ensure that they are on par.

Finally, the study concludes by noting that the majority of the participants were excited about the possibility of the implementation of blended learning in a Technology Education course.

b) Article 1 Scholarly Contribution

Article 1 contributes to the existing literature by highlighting how future educators view the integration of online and face-to-face learning modes. Understanding these perceptions is crucial for designing effective blended learning approaches in practical-based courses. Furthermore, these perceptions and understand outline the needs and expectations of preservice teachers that should be met. Various studies reported on the opportunities and challenges experienced when implementing blended learning approaches (Abdurahman and Ahmad 2022; Aslan, 2020; Attard & Holmes, 2020; Chan, 2019; du Toit & Pool, 2020; Edannur & Marie, 2017; Janse van Rensburg & Oguttu, 2022; Ketsman, 2022; McGuinness & Fulton, 2019, Namyssova et al., 2019; O'Connor et al., 2011; Tshabalala et al., 2014; Ubah et al., 2020; Yilmaz and Malone, 2020; Zimba et al., 2021), whilst very few respond to the challenges within the context of Technology Education (Gumbo, 2020; Mapotse, 2017; Mudenda et al., 2023; Mulaudzi et al., 2023; Pappa et al., 2024). Therefore, the article offers practical recommendations for implementing blended learning in Technology Education, a field that heavily relies on practical, hands-on activities. By suggesting specific approaches, such as presenting theory online and conducting practical classes face-to-face, the article provides a framework that can be adopted and adapted by other educators and institutions. This can help bridge the gap between theoretical knowledge and practical application, enhancing the overall learning experience.

Furthermore, the findings emphasize how online and face-to-face classes can complement each other, leading to improved learning outcomes, flexibility, convenience, and enhanced research skills and technological literacy. This highlights the potential of blended learning to create a more holistic and effective educational experience. The identification of commonly used applications (emails, LMS, WhatsApp) also provides practical insights into the tools that can facilitate blended learning. In addition, the findings outline how preservice teachers can assess their progress, maintain motivation throughout the course, manage time and workload, and gain necessary technological knowledge and skills. These findings contribute to the understanding of self-regulated learning in blended environments in practical-based courses. By identifying specific

strategies that preservice teachers can use, the article offers practical guidance for fostering self-regulation and motivation, which are critical for successful learning outcomes.

Finally, the article findings identify potential challenges and concerns associated with blended learning within a South African context and offers possible solutions to address them. By highlighting the importance of regular, constructive feedback and the need for interaction between instructors and students, the article findings provide actionable recommendations for enhancing engagement and ensuring the effectiveness of blended learning approaches.

In summary, the article makes significant scholarly contributions by providing a comprehensive understanding of preservice teachers' perceptions and understanding of blended learning. The positive response from preservice teachers regarding the implementation of blended learning in Technology Education indicates a readiness and excitement for this approach. This finding can encourage educational institutions to adopt blended learning approaches, knowing that there is a supportive and enthusiastic student base.

4.2.2 Article 2 Findings and Scholarly Contribution

Article 2, titled “Profiling the engagement patterns of preservice teaching in a blended learning Technology Education class at a South African institution”, addresses the second research question; more specifically, the article reports on preservice teachers’ engagement in a blended learning Technology Education class in a South African institution.

a) Article 2 Findings

Based on the findings, It is suggested that the three-phase approach be adopted. Within phase 1, theoretical knowledge should be presented virtually, and recordings and resources be made available for users to download or refer to. The findings indicated that preservice teachers had accessed the recordings and slides on numerous occasions throughout the 6 weeks. This could indicate that preservice teachers referred to content

as a means to make up for a class missed or as a reference when designing and constructing the project.

Phase 2 consisted of the engagement with the design process. More specifically, their engagement in investigating, designing, constructing, evaluating, and communicating. For investigating, it was found that preservice teachers were able to design creative and unique scenarios that complemented the outline of the project. This could indicate that preservice teachers applied their critical thinking and problem-solving skills. Furthermore, online resources, such as including YouTube videos, TikTok videos, Pinterest, online articles, online textbooks, and online DIY projects, assisted them in their investigation. It is assumed that online learning works best for the investigation step.

For designing, the analysis of preservice teachers' design process portfolios indicated that some preservice teachers were able to communicate their intent through graphical communication. However, for others, there was a lack of effort and ability to graphically communicate their ideas. This could therefore indicate a lack of knowledge application. Also noted was that some preservice teachers lacked knowledge on how gear systems should work (i.e., teeth must mesh; three gears cannot be linked to each other at once or it will jam the system; different shapes and sizes require deeper thought to create a working gear system). It is further noted that for others, the designs indicated only interlocking gears and not necessarily a solution to the scenario. In addition, although the design of the gear system required preservice teachers to draw, this step can be grouped into face-to-face and online, as preservice teachers indicated that they received inspiration for their designs from online sources.

For constructing, preservice teachers grouped themselves according to convenience and familiarity. Thereafter, they decided on a single scenario and design. Preservice teachers could make their gear system in the technology laboratory or at another venue. Those who did not meet at the technology laboratory had indicated that they met on the campus but at another venue. Only two groups indicated that they met "at home". Furthermore, preservice teachers were asked what they most and least enjoyed about making the gear system. From this, the following themes emerged in which both positive and negative comments were noted: (i) creating; (ii) group engagement and

collaboration; and (iii) the final product. In addition, various challenges associated with the groups were identified and overcome. This included group members coming late or not appearing for meetings which was resolved by group members being reprimanded; the inability to decide on a design which was resolved by voting; and procrastination which was resolved by the group member intervening and discussing the importance of the project.

For evaluation, preservice teachers were asked how satisfied they were with their gear system on a scale from 1 (very dissatisfied) to 5 (very satisfied). From the results, 90% of preservice teachers indicated that they were either satisfied or very satisfied, 9.5% indicated that they were neutral, and 0.5% indicated that they were very dissatisfied. Furthermore, preservice teachers were asked to reflect on how their gear system could be improved. Amongst the suggestions were to use stronger or better materials, to decorate the final product, and to improve functionality. One group indicated that it could be improved by knowing more about gears and how they work, while another group stated that more research should be undertaken.

For communicating, preservice teachers indicated that WhatsApp was the only online communication tool used. In addition, they communicated face-to-face when meeting and making the gear system. The majority indicated that they had met once or twice per week, whereas very few indicated three or four times per week. Furthermore, preservice teachers indicated that they primarily engaged with peers or the instructor outside of their group.

Phase 3 consisted of project presentation and evaluation in the face-to-face classes. Groups were assessed on their presentation skills and the demonstration of the functioning gear system. Furthermore, the gear systems were assessed on the functionality, creativity uniqueness, and recyclable materials used, with the use of a rubric.

b) Article 2 Scholarly Contribution

The article proposes a structured three-phase approach to blended learning in Technology Education, which includes online classes focused on theoretical knowledge,

engagement with the design process, and face-to-face project presentation and evaluation. This model provides a clear framework that can be adopted and adapted by other educators and institutions. This contributes to the development of effective blended learning strategies in practical-based courses. As various studies highlight how blended leaning can be implemented in Science, Technology, Engineering, and Mathematics (STEM) Education (Candido et al., 2023; Puspitasari et al., 2020; Rachmawati, 2019; Supriyadi et al., 2023), this article focus is on Technology Education that addresses the gap identified by Mulaudzi et al. (2023). Furthermore, the findings contribute to the understanding of how digital resources can be effectively integrated into Technology Education to support student learning.

Noted by Gumbo (2020) and Mulaudzi et al. (2023), Technology Education must be taught differently from other subjects due to its practical nature. The article thus contributes to the literature on the development of critical thinking and problem-solving abilities in blended learning approaches, and further highlights the need for targeted instructional strategies to improve graphical communication skills. This provides insights into specific areas where preservice teachers may require additional support, contributing to the development of more effective teaching training programmes in Technology Education (Gumbo, 2020; Mapotse, 2017; Pudi, 2007).

Finally, the high levels of satisfaction reported by preservice teachers, along with their reflections on how to improve their practical tasks (i.e., gear systems in this article), indicate the value of incorporating reflective practice into blended learning. The findings further contribute to the understanding of how different communication tools can be leveraged to support collaboration and interaction in Technology Education. These contributions can inform future research, guide educational practices, and support the development of effective blended learning approaches implemented in practical-based courses such as Technology Education.

4.2.3 Article 3 Findings and Scholarly Contribution

Article 3, titled “Reported perceptions of preservice teachers on blended learning in a Technology Education class”, addresses the third research question; more

specifically, the article aimed to report on the experiences of preservice teachers' engagement in a blended learning approach in Technology Education at a university level.

a) Article 3 Findings

Respondents were asked for information, such as demographics, access to resources, an outline of the common concerns they faced concerning blended learning activities, and items related to the CoI framework. A total of 93 senior and further education and training (FET) phase preservice teachers responded to the survey. From the findings, the majority of the participants were between the ages of 18 – 20, of which, 58 were female and 35 were male. The results further indicated that 84.9% of participants had access to the internet, either most or all of the time. The majority had made use of the Global Protect Application followed by uncapped Wi-Fi at home. Very few responded as having access to the campus Wi-Fi, which suggests that they did not attend online classes on campus. Respondents also indicated that they used between 500mb to 5 gigs per week. Laptops and smartphones were the most common digital devices used for learning.

Furthermore, the common concerns faced with blended learning, missing deadlines, being unprepared, and having no additional data needed for the global protect app were the main challenges highlighted. However, additional challenges, such as internet instabilities, lack of data, and confusion regarding online and face-to-face classes were added.

For the teaching, cognitive, and social presence relating to the CoI survey, all average means per item were 3.82 and above. This indicates that overall, the respondents had a positive response to the items within the survey, and therefore towards the blended learning activity implemented in Technology Education. Consequently, this indicates that the preservice teachers had a positive experience overall with the blended learning approach in Technology Education. The teaching presence received the highest mean score average of 4.42 among the three presences. This suggests that the preservice teachers had an overall positive experience in the blended learning approach that was implemented in the Technology Education course. Furthermore, this suggests

that the preservice teachers perceived the instructor as effective in designing, facilitating, and directing the blended learning processes. It was noted that feedback is essential, must be given promptly, and should be constructive towards course outcomes. In addition, it would be advantageous if preservice teachers were grouped by the instructor or, if the instructor intervened to assist with group formations. In addition, communicating clear timelines would also be helpful.

The cognitive presence refers to the ability to which the preservice teachers engage in reflection and critical thinking to construct their knowledge and understanding. Furthermore, the cognitive presence can provide insight into the quality of collaborative problem-solving as well. The cognitive presence scored the second highest with an average mean score of 4.16, suggesting that preservice teachers were able to construct and engage meaningfully in content through reflection and critical thinking. The findings advocate that the practical activities did not relate to real-life problems. This poses a concern to the researcher, as it could indicate that there was not a strong alignment of activities with Technological outcomes. Therefore, this impacts the learning process and could result in poor learning experiences for preservice teachers if there is no intervention. Moreover, this could also hinder the development of technological literacy amongst the preservice teachers. Furthermore, some preservice teachers indicated that they did not engage much in researching information or active inquiry when doing activities. This may reduce the depth of understanding in their problem-solving, critical thinking, and creative skills. Preservice teachers also indicated that they engaged in meaningful learning experiences when they could apply the knowledge and skills learnt in real-world contexts. This finding also suggests that there is incoherence between the knowledge, skills, and resources gained in theory classes and the practical-based activities.

The social presence scored the lowest average mean score, implying that preservice teachers were not comfortable interacting online. This could be because the blended learning approach was implemented at year-year level, whereas the participants had been engaged primarily in face-to-face learning at schools. However, it could also be

because of the unfamiliarity of the learning management system and preference for traditional learning. The findings indicate that preservice teachers were not comfortable voicing their opinions; that they preferred not to engage in online platforms, and that they felt isolated from the class. However, it is further noted that participants indicated that they felt comfortable interacting with other course participants. This could confirm that the Technology Education course was designed to create learning communities that encouraged preservice teachers to engage with others to form learning communities. This could be through discussions in class or engaging with knowledgeable others for information. Additional findings suggest that preservice teachers knew how to engage in class.

Furthermore, the researcher sought to test for significant differences using t-tests, Analysis of Variance (ANOVA), and post-hoc Tukey HSD test. From the findings, there were no statistically significant differences found between the CoI elements and (i) gender, and (ii) age. This suggests that the blended learning approach is perceived similarly across genders and age groups, highlighting its broad applicability and inclusivity in Technology Education. The article also tested whether there was statistical significance between the CoI elements and preservice teachers' eagerness to engage in blended learning activities. This was done using the ANOVA. The results showed no statistically significant difference in teaching presence ($p=0.059$), but a trend towards significance suggests potential underlying differences. However, significant differences were found for cognitive presence and social presence, indicating that eagerness to engage in blended learning approaches significantly influences these CoI elements. These results highlight the importance of students' attitudes and motivations in their learning experiences. The significant differences in cognitive and social presence suggest that these aspects are influenced by students' eagerness to engage in blended learning activities.

Furthermore, using ANOVA, the researcher tested to see the statistical significance between (i) constant (i.e., always/all the time), (ii) mostly constant (i.e., mostly have access), and (iii) intermittent (i.e., sometimes) access to stable and reliable internet. The results indicate that preservice teachers with constant stable and reliable internet connection reported higher teaching, cognitive, and social presences compared to those

with intermittent access. As anticipated, the results suggests that reliable internet access is crucial for effective teaching presence in blended learning environments. However, it is important to note that even with reliable internet access, other factors such as the quality of online resources, the level of instructor support, and the students' prior technological experience could also significantly influence their overall engagement and learning outcomes. Therefore, while ensuring stable internet connectivity is essential, a holistic approach that addresses these additional factors is necessary to fully optimize the blended learning experience.

b) Article 3 Scholarly Contribution

The article aimed to report on the experiences of preservice teachers' engagement in a blended learning approach in Technology Education at a university level. Various studies assert the need for teacher training programmes to develop strategies to enhance Technology teaching and learning processes to ensure the production of well-prepared Technology teachers (de Vries, 2000; Gumbo, 2016; Mapotse, 2017; Pappa, 2024; Seleke, Speight Vaughn, & de Beer, 2018, Teis and Els, 2021). The findings from this article can thus make significant scholarly contributions to the field of Technology Education and blended learning. This includes insights into preservice teachers' access to resources, such as internet connectivity and digital devices from a South African perspective. This is valuable for understanding the context in which blended learning is implemented and can inform future studies on the accessibility and equity of educational technologies. Furthermore, the findings outline common concerns and challenges faced by preservice teachers, such as missing deadlines, being unprepared, and internet instabilities, the study highlights the practical issues that need to be addressed to improve the effectiveness of blended learning. This contributes to the literature by providing a nuanced understanding of the barriers to successful blended learning implementation.

Furthermore, Clark et al. (2016:2) report that the teaching of technical subjects using traditional methods "is emerging as an ineffective and inferior method of instruction". As such, the article findings reports that preservice teachers had an overall positive experience with the blended learning approach, as indicated by high average mean scores for teaching, cognitive, and social presence. This finding supports the

effectiveness of blended learning approaches in Technology Education and adds to the body of evidence that blended learning can enhance student engagement and learning outcomes. In addition, the lack of significant differences in the perception of the CoI elements across genders and age groups suggests that the blended learning approach is inclusive and broadly applicable. This finding supports the idea that blended learning can be effectively implemented across diverse student populations.

Finally, the article findings underscore the critical role of stable internet connectivity in blended learning environments. In addition, other factors such as the quality of online resources, instructor support, and students' prior technological experience also significantly influence learning outcomes. This provides contributing perspectives that can be considered when developing and implementing blended learning approaches in related courses.

4.3 DEVELOPING A CONCEPTUAL FRAMEWORK

The main research question of this study asks, “How do South African preservice teachers experience blended learning in a Technology Education class?”. Subsequently, three secondary questions guided the researcher to answer the main research question by focusing on perceptions, understanding, engagement, and experiences of a blended learning approach implemented in Technology Education.

To elaborate, a blended learning approaches can offer many benefits and opportunities for learning in Technology Education; however, blended learning can also pose problems and concerns if not implemented carefully. Technology Education courses should be designed, implemented, and facilitated to ensure that theoretical knowledge is directly linked to authentic, practical activities. In addition, it is crucial to manage preservice teachers' expectations. Feedback should be regular and constructive, as this could affect motivation and engagement. Accordingly, blended learning approaches should be designed to encourage interaction between the instructor and preservice teachers.

In this study, the researcher considered various literature on blended learning, and developed and implemented the three-phase conceptual blended learning model in 2022 to respond to the new norm. Figure 4.1 outlines the conceptual blended learning model.

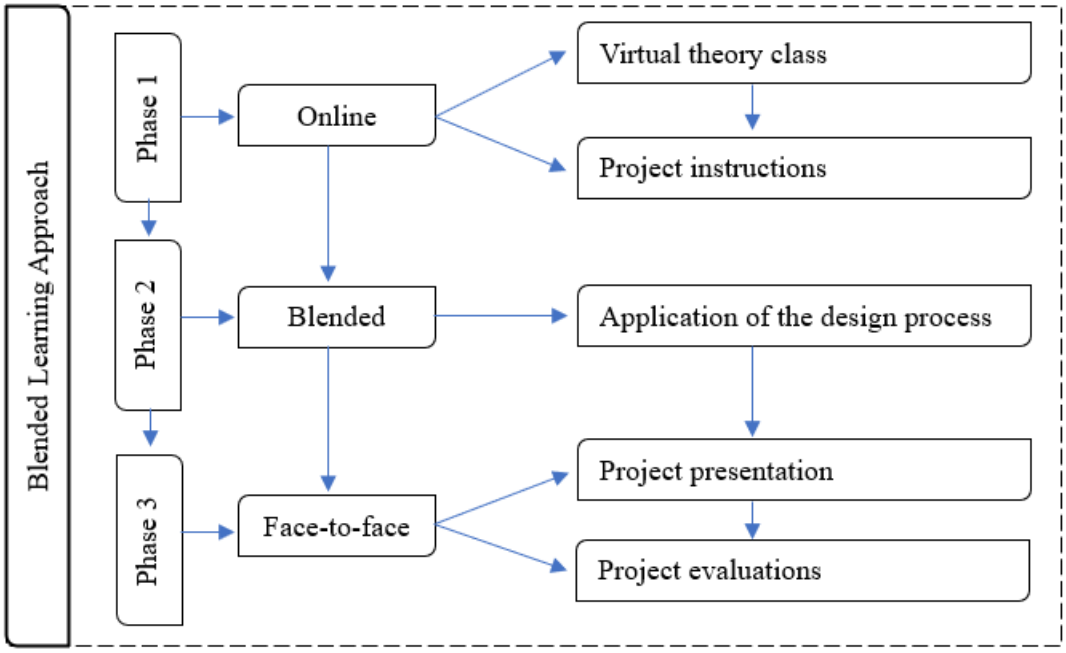


Figure 4.1: Technology Education Blended Learning Model

As the model was initially designed by the researcher, it lacked the insight of the preservice teacher group which would provide critical understanding unique to the South African Technology Education course. Thus, in 2023, preservice teachers responded to open-ended interview questions to respond to research question 1, which asks, “How do Technology Education preservice teachers perceive and understand blended learning within a university context? Presented in Article 1: Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university, the findings supported the design of phase 1 and phase 3. That is, the findings supported the online theoretical classes (phase 1) and face-to-face project presentations and evaluations in phase 3. Furthermore, the findings suggest that Technology Education preservice teachers consider the implementation of a blended learning approach as recommendable and essential for the contemporary changes in the education sphere.

However, the engagement and experiences of preservice teachers in Technology Education was not clear. As such, the researcher included a middle phase (i.e., phase 2). Within this phase, the researcher wanted to understand *how* preservice teachers would engage in a blended learning approach implemented in a practical-based activity. More specifically, *how* preservice teachers would engage in a blended learning approach implemented in the design process as outlined in Figure 4.2.

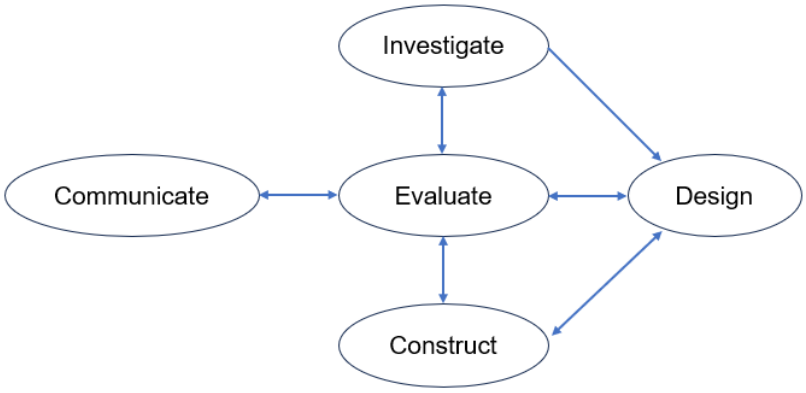


Figure 4.2: The design process in Technology Education (Adapted from DBE [South Africa, 2011:10])

The responses were collected through the document analysis, more specifically, individual and group portfolio, that outlined how preservice teachers engaged in the design process. This was guided by the second research question which asks, “How are preservice teachers engaged in blended learning Technology Education courses in South Africa?”. From the findings presented in Article 2: Profiling the engagement patterns of preservice teaching in a blended learning Technology Education class at a South African institution, the following supplementary blended learning approach was developed. This model, presented in Figure 4.3, highlights *how* preservice teachers engaged in each step of the design process; that is, if their engagement with face-to-face or online.

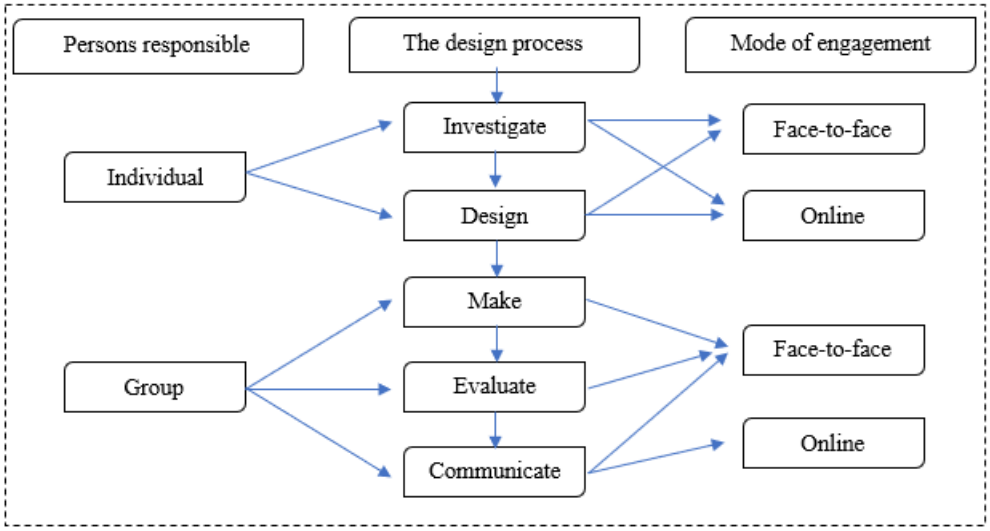


Figure 4.3: Implementation of the blended learning design process approach

These findings suggest that preservice teachers engaged in a blended mode when participating in the portfolios and thus, when engaging with the design process. The findings indicated that preservice teachers engaged in the investigate, design, and communicate steps both online and face-to-face; while they only engaged face-to-face in the make and evaluate steps.

More specifically, the findings indicate that for the investigate step, majority of preservice teachers consulted online resources (online articles, textbooks, and DIY projects), which included social media (YouTube videos, TikTok videos, Pinterest). This highlights the need for a dedicated research platform that is tailored to the specific needs of preservice teachers. Such a platform would provide reliable resources, ensuring that preservice teachers can access high quality information, without resorting to potentially unreliable online sources. This would also aid in streamlining their investigation that could enhance the overall quality and relevance of their final product.

Within the design step, the findings indicated that preservice teachers made use of ICTs and traditional methods (i.e., drawing on paper) to complete their designs. However, this step is identified as both online and face-to-face as preservice teachers received inspiration from online sources to support their designs. Their engagement with the group to finalise the design was also online and face-to-face, indicating the need to create environments for engaging, sharing, and collaborating.

For the making step, preservice teachers indicated that they met face-to-face at various spaces which included the formal lab allocated to Technology Education, group members respective homes, or alternative venues. This highlights the flexibility of the project in terms of collaboration and location. Furthermore, the approach accommodates different preservice teacher preferences and circumstances which allows for more adaptable and inclusive learning experiences. The evaluation step was also completed face-to-face as students would physically test their gear system in their respective groups, and then present it as part of phase 3 of the Technology Education Blended Learning Model (see Figure 4.1).

Finally, throughout their engagement in the design process, preservice teachers would need to communicate. This is an integral part of the overall process. Within this step, preservice teachers indicated that they had engaged face-to-face and online with various stakeholders such as group members, other groups, the lecturer, and more knowledgeable others.

To conclude the study, the researcher needed to understand how preservice teachers experienced the blended learning approach. The findings were captured in Article 3: Reported perceptions of preservice teachers on blended learning in a Technology Education class. Specifically, the findings are responses to the Community of Inquiry (CoI) survey, which was developed to assess the effectiveness of online and blended learning environments. To elaborate, the survey measures three key elements which are crucial for creating meaningful and engaging educational experiences. These elements are the teaching, cognitive, and social presences. The overall findings from the CoI survey indicated that preservice teachers had a positive response towards the blended learning approach implemented in Technology Education. In addition, the findings present statistically significant insight into the relationship between eagerness to engage in blended learning approaches and the CoI elements; as well as the relationship between stable and reliable internet connections and the CoI elements. Suggesting that eagerness and internet connections impact on how students engage in blended learning approaches.

Overall, the findings in article 3 support the conceptual framework developed. Thus, blended learning approaches can effectively be implemented in a practical-based course, such as Technology Education. It requires that factors, such as digital devices that have access to stable and reliable internet be initially considered when planning the course. It also requires that the instructor be mindful of common concerns which can be observed by communicating all information timeously and clearly, as well as being mindful of unavoidable technical difficulties.

4.4 THEORIZING THE CONCEPTUAL FRAMEWORK

The design process entails the inception of an idea to solve a problem or need and concludes with evaluating and communicating the result. This engages and develop learners design thinking skills. According to Li, Schoenfeld, diSessa, Graesser, Benson, English, and Duschl (2019:94), design thinking skills “encourage different perspectives and approaches in viewing and solving problems [and] are vital to creativity and innovation”. As it is the backbone of Technology (DBE, 2011), pedagogical practices are influenced by how it can be implemented within classrooms. Furthermore, as we adapt to a new norm and maintain to keep up to date with twenty first century advancements, we are obligated to explore pedagogical practices that keep up to date with modern advancements. Figure 4.3 proposes a conceptual framework for the implementation of a blended learning design process approach. For the purpose of discussing the proposed conceptual framework for future studies, the term “learners” can refer to students, preservice teachers, or the user who is engaging in the design process.

The design process consists of several steps, namely investigating, designing, making, evaluating, and communicating. In the initial two steps of the design process, that is, the investigate and design steps, an individual approach should be adopted. This ensures that learners actively engage with the content and the design process to ensure that they can respond to what is expected. By adopting this approach, the mentor teacher can ensure that the learners are actively involved with the core competencies required by the CAPS document, such as design skills, investigative skills, innovation, creativity, and problem-solving skills (DBE, 2011). As the last three steps of the design process are

completed in groups, the individual contributions ensures that learners can provide personal insights from their own investigation and design, allowing for skill development for both personal and professional growth. Furthermore, the individual designs allow learners to engage in critical reflections (Novica, Wianto, Campos, 2023) and encourage deeper research activities as learners engage in the investigation and design steps from different perspectives.

Furthermore, it is recommended that the last three steps of the design process, that is, the make, evaluate, and communicate steps, should adopt a group approach. By doing so, it ensures that resources are effectively used and managed, and that the time available is used more effectively. Furthermore, engaging in group activities within the design process, allows learners to share and critically compare ideas and solutions. As found by Gokhale (1995:28), “students who participated in collaborative learning had performed significantly better on the critical-thinking test than students who studied individually”. Noted by Kelly and Cunningham (2019), engaging in such processes allows learners to make important changes and adaptations to their groups designs to ensure that the required outcome is met. Further, as noted by various studies, there are limited classroom resources and sessions allocated to Technology Education within schools (Dinc, 2019; Mapotse, 2012; Mapotse & Gumbo, 2012). By adopting a group approach, it minimizes the space needed to display the project of each learner, and it ensures that time is used more effectively as there is a shared workload. Furthermore, engaging in a group ensures collaborative and problem-solving skills are developed (Brame & Biel, 2015). In addition, by collaborating in a group, it allows each learner to share their unique and diverse skills, which enhances the quality of the design process. As the learners had already investigated and designed their solution to the given problem/need, working together with others could spark new ideas or combinations of ideas and solutions (group brainstorming). In addition, working together ensures shared responsibility, accountability, and enhanced presentations.

Investigate

For the investigation step, it is suggested that face-to-face and online engagement activities are implemented. Learners can partake in face-to-face activities by highlighting

the need to engage with knowledgeable others. As part of the work proposed by Gumbo (2015), Gumbo and Gaotlhobogwe (2021), and Khumalo and Mapotse (2023), there is a need to include indigenous knowledge systems into the curriculum. These authors elaborate that consulting knowledgeable others could also ensure engagement with the community, as well as their involvement in ensuring that the practical skills are met. Their involvement also entails sustainable learning to ensure that, for example, when projects should be made out of recyclable materials, different ways of working with and preserving materials could be incorporated. This provides opportunities for collaboration and networking. Face-to-face engagement also provides hands-on research opportunities such as reading books, working with available materials, and engaging with previous projects and prototypes.

Furthermore, online resources can enhance ideas, provide visual imaging, and help learners make connections (Yang & Baldwin, 2020). It also has the potential to provide step-by-step guides to completing tasks. These online resources provide a different point of view, which encourages out-of-the-box thinking and encourages learners to critically engage with which solution is most applicable and appropriate. Online resources also provide learners with a wider range of resources that can be used or included (e.g., YouTube videos, TikTok, Pinterest, online articles, online textbooks, DIY projects). In addition, online resources are convenient as mobile phones and laptops provide access to a range of information that provides recent and contemporary information.

Design

For the design step, a face-to-face and online approach is also suggested. This entails learners engaging with different graphical communication techniques such as isometric, oblique, orthographic, and perspective drawings as required by the CAPS document (DBE, 2011). This ensures that theoretical components relate to practical components, and that designs are relevant. As noted by Novica et al. (2023:2), designing requires that learners are systematically and critically involved in defining and redefining “inclusion criteria, identifying and selecting primary research, extracting data, and critical appraising of relevant research”. As such, it provides opportunities to enhances

imagination, higher order thinking skills, and creativity skills (Joordens, Chandrasekaran, Stojcevski, & Littlefair, 2012) by ensuring that it meets the criteria of the given problem/need and proposed solution. As learners engage and share their designs with the mentor teacher, it provides them with an opportunity to receive immediate feedback and guidance. Further noted by Novica et al. (2023:8), “teacher interventions are also crucial in design learning, such as providing a supportive and encouraging learning environment”. This ensures that learners know the what and the how of resolving the problem/need, and that they receive feedback valuable to progressing into the group work phase (Novica et al, 2023; Self, 2017). Online engagements further allow the learners to engage with relevant design tools and computer-aided design platforms such as SketchUp, Canva, Adobe Illustrator, TurboCAD, AutoCAD, and TinkerCAD, which can be used to graphically communicate final designs. Online tools can also provide shared working spaces, which encourage collaboration and improve designs.

Make and Evaluate

For the making and evaluation steps, a face-to-face approach must be adopted. A face-to-face approach ensures that the final solution and design have materialized. Naturally, it would be better to physically evaluate the final project rather than to evaluate it online. This is also confirmed with Schmidt, Montoya-Wriss, and Massey (2001) who state that face-to-face interactions are more personal and friendly compared to online evaluation and communication environments. As part of the expectations of Technology, as a practical-based course, making requires hands-on engagement (Sianez, Fugère, & Lennon, 2010). By doing so, it also ensures that problem-solving skills are developed and enhanced as the learners make and evaluate the project. Furthermore, face-to-face making and evaluating steps ensure that resources are shared, and group members are held accountable. Practical demonstrations also enhance collaborative skills and allow groups to motivate and hold each other accountable. In addition, conflicts are often resolved better when engaging face-to-face than on online platforms.

Communicate

For the communicating step, a face-to-face and/or an online approach can be adopted. Communication is multi-faceted in this regard as it forms an integral part of each

step within the design process (DBE, 2011). For example, in the previous steps, it required learners to engage with others either face-to-face or on online platforms (i.e., emails, Blackboard Collaborate, Blackboard Discussion boards, WhatsApp, Microsoft Teams, Zoom, and other social media). As noted within the CAPS for Technology, communicating "should show increasing use of media, levels of formality and conventions" (DBE, 2011:12) and can be "oral, written, graphic, or electronic presentations" (DBE, 2011:68). More specifically, when communicating the final design through presentation, it enhances the learner's engagement within the group and allows for team building and creativity. Furthermore, it encourages uniqueness and personalization among presentations (Yu & Yao, 2023) as the learners have various ways in which they can present their project using a variety of ICTs such as Canva, Microsoft PowerPoint, videos, and photo diaries. These authors further highlight that engaging in a blended learning approach to communicating final design provide innovative approaches in practical-based courses such as Technology.

In conclusion, the proposed conceptual framework for a blended learning design process approach in Technology Education offers a strategy to enhance both individual and group learning experiences in a blended mode. By integrating face-to-face and online engagement, this approach ensures that learners develop essential design thinking skills, such as creativity, problem-solving, and critical thinking, through individual activities. These skills are further enhanced and applied in groups, whereby collaborative efforts foster innovation, shared responsibility, and effective use of resources. The blended learning design process approach further aims to only addresses the challenges of limited classroom resources and time constraints. Furthermore, it prepares the user for the demands of the twenty-first century by incorporating modern technological advancements and diverse pedagogical practices. Ultimately, this conceptual framework aims to create a dynamic and inclusive learning environment that supports the holistic development of learners by equipping them with the skills and knowledge necessary for success in the dynamic field of Technology Education.

4.5 LIMITATIONS OF THE STUDY

The data in this study were collected over one year, ending in August 2023. The study was a success except for the following limitations:

First, in this study, the sample selection covers one province in South Africa, which is the Free State. The data collection processes used in this study, the analysis of data, the results, and findings, may thus not be representative of other HEIs, as the research study was based on only one selected HEI in a country with 26 HEIs. The research is, however, expected to provide significant insights that can be extended to other courses that offer blended learning.

Second, the study focused primarily on the blended learning approach employed for Technology Education as a practical course. More specifically, the blended learning approach was employed in the design process. Hence, a challenge may arise when applying the findings to other practical subjects, such as the natural sciences, biological sciences, physical sciences, or mathematics.

Third, the data collected to report on preservice teachers' engagement and experiences were over one semester, with one class. Therefore, as such, it is recommended to engage over multiple semesters, and/or with multiple classes to enhance the generality.

Last, the data relied on the participants' honesty in providing reliable and complete information, which is subject to bias and subjectivism. To counter this limitation, three data collection tools were used to triangulate the data, thus, improving confidence in the research findings.

4.6 RECOMMENDATIONS AND CONCLUSION

The results of this study are deemed to have implications in three areas; namely (i) teaching and learning in STEM education; (b) curriculum policies; and (c) future research. This is discussed below.

4.6.1 Implications for teaching and learning in STEM education

According to the literature and the findings presented in this study, blended learning offers many benefits and opportunities for improved engagement. A well-designed blended learning approach implemented in a STEM course could encourage students to engage and take responsibility for their learning. It encourages them to apply their critical thinking and problem-solving skills to resolve problems in creative ways. In addition, it could offer students the opportunity to work individually and collaboratively on tasks, such as the design and creation of a gear system, as outlined in this study. This has a ripple effect, as it can result in better learning outcomes, increased technical knowledge and skills (i.e., technological literacy), and increased levels of motivation and interest.

Furthermore, offering blended learning approaches could also result in flexible learning. This provides students with the opportunity to learn at home, on campus, or wherever they find themselves. Recorded lessons can be accessed frequently and provide a basis for learning. In addition, online resources have been proved to be a source of information, as indicated in the design step in the findings of article 2. Furthermore, their engagement in LMS and other applications, such as Google Forms also assisted in exposure to various platforms of learning.

Blended learning in STEM education also offers opportunities for improved teaching. It requires thoroughly planned activities for online and face-to-face engagement and requires the instructor to rethink their pedagogical approaches to ensure that learning outcomes are met. From this study, the relationship between teaching, cognitive, and social presence is highlighted. The relationship is imperative for understanding online- and blended learning, to ensure that there is a positive educational experience. All presences should be considered when designing and implementing blended learning approaches.

Finally, given the declining interest in STEM education fields, the lack of preparedness and appropriate training and support, and the lack of diversity and gender gaps, it is hoped that this research contributes towards improving teaching and learning.

It is further envisaged that the findings of this study contributes to engagement in STEM education and improve instructional leadership in HEIs.

4.6.2 Implications for Curriculum Policies

The findings of this study also have an impact on the curriculum policies for teacher-training programmes in STEM education in HEIs. As noted previously, the effective design of a blended learning approach can contribute towards the holistic development of Technology Education preservice teachers when the Technology Acceptance Model (TAM) and Community of Inquiry (CoI) frameworks are taken into account. More so, practical-based tasks need to be designed in accordance with the theoretical knowledge presented in class and the application to real-world problems. Thus, curriculum designers and teacher educators should rethink how the three learning domains relate.

Furthermore, curriculum designers and teacher educators could consider the technological and infrastructural needs to support blended learning approaches in practical-based courses. For example, the findings in this study suggest a need for either a smartphone or laptop to access classes, recordings, and resources. In addition, a smartphone was deemed essential for preservice teachers to communicate via WhatsApp with group members, and data usage should be taken into consideration. Furthermore, regarding infrastructural needs, the preservice teachers in this study had worked either in the laboratory or on campus, with very few indicating that they had completed their projects at home; thus, the facilities and space to complete the project should be available in the above-mentioned venues. In addition, preservice teachers noted that the materials needed for the project should be provided, rather than having to use recycled materials. It would also be helpful to have a space where preservice teachers could store their projects, as well as a space where they could meet.

Finally, curriculum developers could consider the need for training for both the preservice teachers and the teacher educators regarding the LMS. As noted in this study, preservice teachers were reluctant to engage online. Ensuring that they are familiar with the LMS could result in higher participation levels. Furthermore, the teacher educator

could also receive training on how to encourage participation through the use of the LMS, such as probing questions, polls, voice chats, chat boxes, discussion boards, and so forth.

4.6.3 Implications for Future Research

This study provides a conceptual framework for the application of a blended learning approach in Technology Education. Further research could implement the conceptual framework approach in a study, by examining the effect on student engagement; learning outcomes; motivation and interest, and improved learning experiences. Future research could also respond to the most effective ways to improve teacher-training programmes and the impact of different teaching and learning approaches. Future research could also include a methodological study/paper. Investigating the specific processes and techniques used when implementing the conceptual framework could further enhance the framework.

In addition, the need for the implementation and use of information and communications technologies (ICTs) in HEI courses could be explored. The needs of preservice teachers and teacher educators could be better understood in terms of the ICTs, training, and the integration of ICTs in courses.

The interrelationship of the three elements of CoI could also be explored; that is, the interrelationship between the cognitive, teaching, and social presence can be studied. Outlining how the educational experience can be enhances through supporting discourse, setting climate, and regulating learning can provide suggestions on how to develop holistic learning environments and create effective online and blended learning environments.

It is hoped that this study encourages policymakers and instructors to review the benefits of integrating blended learning approaches in STEM education fields, such as Technology Education. However, the findings presented are limited only to the engagement of preservice teachers in a blended learning approach, implemented in Technology Education over one semester. The study could therefore be repeated, and the results, benefits, and challenges associated with this approach reported on.

4.6.4 Conclusion

The Covid-19 pandemic brought about many changes within the education system that resulted in different teaching and learning approaches being implemented in a very short period. Fortunately, the introduction of online and blended learning approaches gained momentum, and the effects and benefits of these approaches cannot be ignored. This is especially true of STEM education courses which require practical skills and knowledge to be achieved. The study aimed to explore preservice teachers' experiences of blended learning in Technology Education. Open-ended interview questions, document analysis, and a survey were used to respond to preservice teachers' perceptions and understanding, engagement, and experiences, respectively. From the data, a conceptual framework emerged, the first of its kind for the implementation of a blended learning approach in a practical-based activity, within a Technology Education course for third-year level students.

In conclusion, the conceptual framework developed for blended learning in Technology Education has important implications for teaching and learning, curriculum policies, and future research. By continuing to study the potential benefits and challenges offered by blended learning approaches offered in STEM education courses in teacher-training programmes, researchers can ensure that the teachers of tomorrow are prepared and ready to succeed in the digital age of the 21st century.

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Appendix A. Ethical statements

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

02-Sep-2021

Dear Miss Zaynab Mobara

Application Approved

Research Project Title:
Case Studies on South African Preservice Teachers' Experiences of Blended Learning in Technology Education

Ethical Clearance number:
UFS-HSD2021/0996/21

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Dr Adri du Plessis
Digitally signed by Dr Adri du Plessis
Date: 2021.09.06 11:52:23 +02'00'

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UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

30-Aug-2022

Dear Miss Zaynab Mobara Z

Amendment Approved

Research Project Title:
Case Studies on South African Preservice Teachers' Experiences of Blended Learning in Technology Education

Ethical Clearance number:
UFS-HSD2021/0996/21

We are pleased to inform you that your amendment application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for notifying the ethics committee of the changes/amendments that have been made to your study; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Dr Adri du Plessis
Digitally signed by Dr Adri du Plessis
Date: 2022.08.30 15:09:44 +02'00'

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Appendix B. Language editing

20 October 2024

72 Devereux Ave.
Vincent 5201
East London
South Africa

Student: Zaynab Mobara-Links

This is to state that the PhD thesis: 'Case Studies on South African Preservice Teachers' Experience…' (text only), submitted to me by Ms Z. Mobara-Links (student number: 2009108461) of the University of the Free State, South Africa, has been language edited by me, according to the tenets of academic discourse.

Mrs Carol Julia Keep

MA (English); BEd (Hons.); Teachers Diploma; Cert. of Proofreading

Rephrase it!
Academic Text Editing

17 Fallopius Street, Bloemfontein
+(27) 076 081 0730
info@rephraseit.co.za

2 December 2024

Authors: **Z Mobara-Links and T Jita**

I declare that I edited the academic article titled, *Understanding blended learning in a practical-based course: Insights from Technology Education preservice teachers in a South African university*

During the editing process, I looked for and corrected spelling, grammar, punctuation, sentence and paragraph errors. Where I noticed inconsistencies or unclarities in the text, I made comments to draw the authors' attention to the inconsistency or unclarity. I also made suggestions where changes could be made. I double-checked the references in-text and in the reference list to make sure that they are consistent throughout. Where sources or source information were missing, I indicated such to the authors so that they could locate and add the missing information.

Yours sincerely

Johannes Pieter Odendaal

Rephrase it!
Academic Text Editing

17 Fallopius Street, Bloemfontein
+(27) 076 081 0730
info@rephraseit.co.za

3 December 2024

Authors: **Z Mobara-Links and T Jita**

I declare that I edited the academic article titled, *Profiling the engagement patterns of preservice teaching in a blended learning Technology Education class at a South African institution*

During the editing process, I looked for and corrected spelling, grammar, punctuation, sentence and paragraph errors. Where I noticed inconsistencies or unclarities in the text, I made comments to draw the authors' attention to the inconsistency or unclarity. I also made suggestions where changes could be made. I double-checked the references in-text and in the reference list to make sure that they are consistent throughout. Where sources or source information were missing, I indicated such to the authors so that they could locate and add the missing information.

Yours sincerely

Johannes Pieter Odendaal

Rephrase it!
Academic Text Editing

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info@rephraseit.co.za

3 December 2024

Authors: **Z Mobara-Links and T Jita**

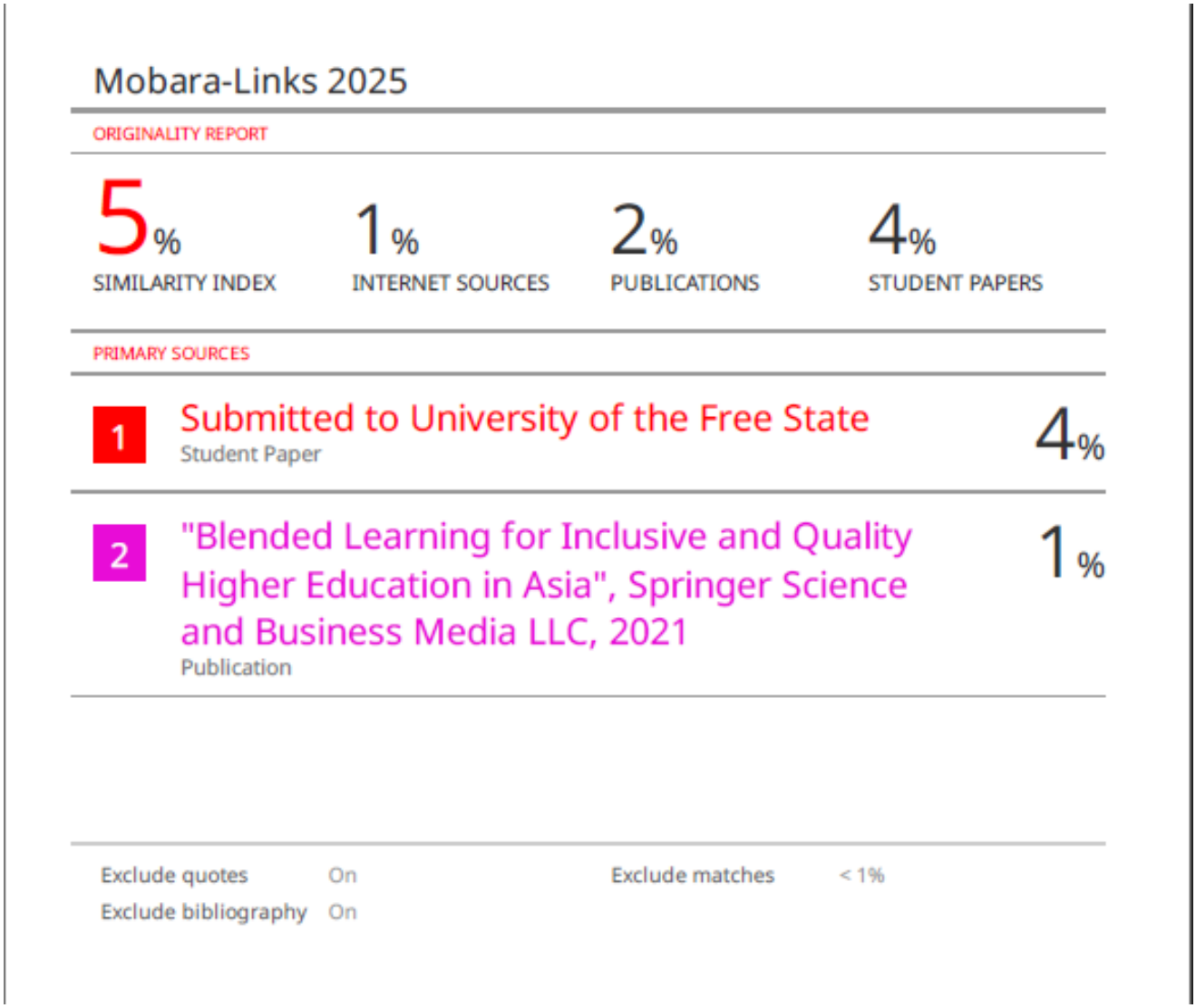
I declare that I edited the academic article titled, *Reported perceptions of preservice teachers on blended learning in a Technology Education class*

During the editing process, I looked for and corrected spelling, grammar, punctuation, sentence and paragraph errors. Where I noticed inconsistencies or unclarities in the text, I made comments to draw the authors' attention to the inconsistency or unclarity. I also made suggestions where changes could be made. I double-checked the references in-text and in the reference list to make sure that they are consistent throughout. Where sources or source information were missing, I indicated such to the authors so that they could locate and add the missing information.

Yours sincerely

Johannes Pieter Odendaal

Appendix C. TurnItIn report



Mobara-Links 2025

ORIGINALITY REPORT

5%	1%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of the Free State Student Paper	4%
2	"Blended Learning for Inclusive and Quality Higher Education in Asia", Springer Science and Business Media LLC, 2021 Publication	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		

Appendix D. Informed Consent: Head of Institution

Informed Consent: Head of Institution

The Head of Institution,

Dear Sir/Madam/Dr/Prof

My name is Zaynab Mobara-Links, and I am a lecturer and PhD student at the University of the Free State. As part of my doctoral programme, I am doing research on the following topic:

Case Studies on South African Preservice Teachers' Experience of Blended Learning in Technology Education

The aim of this study is to explore how preservice teachers experience blended learning in a Technology Education class. The study also aims to report on preservice teachers' perceptions and expectations of the teaching and learning activities carried out in blended learning approaches, and to outline common patterns in their experiences.

I hereby apply for permission to conduct research at your institution, specifically the final year Technology Education teacher training programme. This will include a survey distributed to all 4th year Technology Education preservice teachers, interviews with one 4th year Technology teacher educator, two observations of blended learning classes (online and/or face-to-face), and individual interviews with six preservice teachers. These data collection processes will not interrupt teaching and learning activities. Such data collection processes will provide meaningful contributions to the literature on blended learning approaches in practical learning subjects for preservice teachers. All results will be shared with your institution. Additionally, informed consent will be requested from all participants.

Thank you for your kind cooperation. Your favourable response will be highly appreciated.

Your sincerely,

Appendix E. Informed Consent: Preservice Teacher Open-Ended Interview Questions

Informed Consent: Preservice Teacher

My name is Zaynab Mobara-Links, and I am a lecturer and PhD student at the University of the Free State. As part of my doctoral programme, I am doing research on the following topic:

Case Studies on South African Preservice Teachers' Experience of Blended Learning in Technology Education

The aim of this study is to explore how preservice teachers experience blended learning in a Technology Education class. The study also aims to report on preservice teachers' perceptions and expectations of the teaching and learning activities carried out in blended learning approaches, and to outline common patterns in their experiences. I would like you to participate in this research because you are involved in the application and teaching of blended learning approaches in Technology Education in a third-year course.

There are no risks involved in the participation in this study and your identity will remain anonymous throughout the publications and reports. Indeed, your contribution will add value to this field of teaching and help to deepen the understanding of the application of blended learning approaches in practical subjects such as Technology Education. While your contribution is highly appreciated and your participation in this important study invaluable, you are under no obligation to partake in the study as your involvement is entirely voluntary. If you do choose to participate, and an issue arises that puts you in discomfort, you may at any time discontinue your involvement without any repercussions.

If you experience any discomfort, unhappiness and/or unpleasantness with the way the research is being conducted, please feel free to contact me or my supervisor (indicated below) to discuss and resolve the matter immediately.

Yours sincerely,

Open-ended questions

1. Have you heard of the concept of Blended Learning before?
2. How familiar are you with the concept of Blended Learning on a scale of 1 (not familiar) to 5 (very familiar).
3. Define blended learning in your own words.
4. Why should a Blended Learning approach be implemented in Technology Education? If you do not think it should be implemented, you can leave this answer blank.
5. What would you say are the benefits of Blended Learning in Technology Education? Provide at least 3 benefits.
6. What would you say are the challenges of Blended Learning in Technology Education? Provide at least 3 challenges.
7. Which approach would you prefer in Technology Education?
8. How would you communicate with your peers if a Blended Learning approach is implemented in Technology Education?
9. How would you communicate with your lecturer if a Blended Learning approach is implemented in Technology Education?
10. If you said online or both, which applications would you use?
11. What devices would you use to access online classes?
12. How often would you expect to have online classes?
13. How often would you expect to meet face-to-face?
14. Which approach do you expect for theory classes?
15. Which approach do you expect for drawing classes?
16. Which approach do you expect for practical classes?
17. How would online and face-to-face classes complement each other?
18. How would you assess your own progress and performance in a blended learning approach?
19. How frequently would you expect feedback?
20. How would Blended Learning affect your motivation and interest in Technology Education? Answer in 3 sentences.

21. How would a Blended Learning approach in Technology Education help you manage your time and academic workload?
22. If a Blended Learning approach was implemented in Technology Education, how would you ensure you are gaining the necessary knowledge and skills?
23. Are you excited about the possibility of a blended learning approach implemented in Technology Education?

Appendix F. Individual Portfolio

Name and Surname:	
Student Number:	
Module Code:	
Submission Date:	

Insert an image of your gear system (this can be drawn)

Assignment

Gears are used to transfer motion and torque between machine components. The size of the gears ultimately determines the gear ratio between two interlocking gears.

1. Design a gear system that compliments a scenario.
2. The gear system must be used to explain mechanical advantage.
3. There must be at least 3 different sized interlocking gears.
4. Each gear must be made of recyclable materials.
5. Marks will be awarded for creativity and uniqueness.

Application of the Technological Process

1. Investigation

Investigate the situation so that an appropriate gear system can be designed to solve the problem, need, or want described in the scenario.

Investigate the possible recyclable material and gear types that can be used together to make the gear system.

2. Design

Write a design brief giving specifications and constraints.

Produce two sketches of viable possible designs.

Examine the individual suggestions, and then decide on a final solution.

1. Investigate

1.1. What is the problem that you want to solve?

1.2. Are you familiar with the content or was additional research necessary? Please elaborate.

1.3. Which resources were found most appropriate and why?

	Resource	Reason
e.g.,	*Cardboard*	*I had recycled cardboard from the cereal box for the base of my gear system.*

1.4. Which sources did you consult? List at least 3 different sources.

e.g., I consulted the following link:
https://www.settinger.net/projects.php?project=gears

2. Design

Include at least three sketches of possible designs for your gear system.

3. Make

3.1. Which design did you choose and why?

3.2. Include at least 2 detailed sketches of the final design.

4. Evaluate/Assess

	Criteria			
1	<u>Investigation</u> There is a clear description of what the problem is and how to solve it.	0: no problem and solution identified.	1: only a problem or only a solution	2: A problem and applicable solution

			has been identified.	have been identified.
	There is a completed list of resources and applicable reasons for choosing the resource. There is a completed list of at least 3 sources.	0: no resources and reasons listed. 0: No sources listed.	2: a list of resources and applicable reasons are provided. 3: a list of sources listed but some sources cannot be found.	6: a completed list of sources is applicable and available.
2	<u>Design</u> Three designs are visible for a teaching aid. The design relates to the solution given.	0: No designs given.	6: three designs given but no effort is made.	12: three accurate and appropriate designs are visible, and each design relates to the solution.
3	<u>Make</u> A reason is given for the selection of the design.	0: No reason given.	1: an applicable and appropriate reason given.	

	Final Design	0: no final design evident.	3: some effort is made in the drawing of the final design. The final design is somewhat accurate, and some to all details are included.	6: effort is made in the drawing of the final design. The final design is accurate, and all details are included.
TOTAL				/29

5. Communicate

N/A

Appendix G. Group Portfolio

1. Investigate
    1.1. How did you choose your group members?
    1.2. What is the problem that your group decided on that you want to solve?
    1.3. What was the role of each of your group members? Provide their name, surname and their student number with their role.
2. Design
    2.1. Why did your group decide on the specific design?
    2.2. Which resources were used and why?
    2.3. Was additional research necessary? If so, what other resources did you consult? (e.g., YouTube link/weblinks/videos, etc.)
3. Make
    3.1. Where did you complete your gear system? (on campus, at home, at a friend's, etc.)
    3.2. Provide evidence of your group planning and making the gear system.
    3.3. What did you enjoy most about making the gear system?
    3.4. What did you enjoy the least about making the gear system?
4. Evaluate
    4.1. Was your gear system tested?
    4.2. How can your gear system be improved?
    4.3. Are you happy with the outcome of your gear system? Select on a scale of 1 (not familiar) to 5 (very familiar)
    4.4. How can this activity be improved?
5. Communicate
    5.1. How did your group communicate with each other?
    5.2. Provide evidence of communication.
    5.3. How often did your group meet per week?
    5.4. Where did your group meet each week?
    5.5. Did you communicate with any other persons? If so, who?
    5.6. Did you encounter any conflicts? If so, how was it resolved?

Appendix H. Informed Consent: Preservice Teacher Survey Questions

Informed Consent: Preservice Teacher

My name is Zaynab Mobara-Links, and I am a lecturer and PhD student at the University of the Free State. As part of my doctoral programme, I am doing research on the following topic:

Case Studies on South African Preservice Teachers' Experience of Blended Learning in Technology Education

The aim of this study is to explore how preservice teachers experience blended learning in a Technology Education class. The study also aims to report on preservice teachers' perceptions and expectations of the teaching and learning activities carried out in blended learning approaches, and to outline common patterns in their experiences. I would like you to participate in this research because you are involved in the application and teaching of blended learning approaches in Technology Education in a third-year course.

There are no risks involved in the participation in this study and your identity will remain anonymous throughout the publications and reports. Indeed, your contribution will add value to this field of teaching and help to deepen the understanding of the application of blended learning approaches in practical subjects such as Technology Education. While your contribution is highly appreciated and your participation in this important study invaluable, you are under no obligation to partake in the study as your involvement is entirely voluntary. If you do choose to participate, and an issue arises that puts you in discomfort, you may at any time discontinue your involvement without any repercussions.

If you experience any discomfort, unhappiness and/or unpleasantness with the way the research is being conducted, please feel free to contact me or my supervisor (indicated below) to discuss and resolve the matter immediately.

Yours sincerely,

Demographics and Access to Resources												
1. Gender	Female			Male				Prefer not to say				
2. Age	18 – 20 years	21 years		22 years	23 years			24 years	25 and older			
3. Programme of study	Bachelor of Education (B.Ed.)			Bachelor of Education (B.Ed.)				Postgraduate Certificate in Education (PGCE)				
4. Area of specialisation	Senior Phase			Senior Phase and FET Phase				Intermediate Phase and Senior Phase				
5. Teaching subject combined with Technology	Natural sciences (NS)	Mathematics		Life science	Engineering graphics and design	Civil Technology		Mechanical Technology	Electrical Technology	Other (please specify)		
6. I have access to a stable and reliable internet connection where I stay.	Always/ All the time	Most of the time		Sometimes				Not at all (I have to travel less than 5km)				Not at all (I have to travel more than 5km)
7. Which of the following do you use to engage in	Desktop Computer	Laptop		Smart phone (internet-capable cell phone)				Cell phone (not internet-capable)	Tablet	Other (please specify)		

online classes?							
8. Which of the following sources of internet do you use to engage in blended learning activities?	Data bundles	Capped Wi-Fi at home	Uncapped Wi-Fi at home	Capped Wi-Fi at other location	Uncapped Wi-Fi at other location	Global Protect App	Other (please specify)
9. How much data would you say you spend on average when engaging online per week?	less than 500mb		between 500mb and 1gig		between 1gig and 5gigs	between 5gigs and 10gigs	more than 10gigs
10. Which of the following would you say concerned you the most with reference	No additional data. I use the Global Protect App	Missing deadlines for assessments	Lack of resources (please elaborate)	Being unprepared for assessments	Cognitive burden	Time-consuming	Other (please specify)

to Blended Learning activities?							

Teaching Presence	1 Strongly Disagree	2	3	4	5 Strongly Agree
The lecturer clearly communicated important course topics and goals.					
The lecturer provided clear instructions on how to participate in course learning activities.					
The lecturer clearly communicated important due dates/time frames for learning activities.					
The lecturer was helpful in identifying areas of agreement and disagreement on course topics that helped me to learn.					
The lecturer was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.					

The lecturer helped keep the course participants on task in a way that helped me to learn.					
The lecturer encouraged course participants to explore new concepts in this course.					
Lecturer actions reinforced the development of a sense of community among course participants.					
The lecturer helped to focus discussion on relevant issues in a way that helped me to learn.					
The lecturer provided feedback that helped me understand my strengths and weaknesses relative to the course's goals and objectives.					
The lecturer provided feedback in a timely fashion.					

Social Presence	1 Strongly Disagree	2	3	4	5 Strongly Agree

Getting to know other course participants gave me a sense of belonging in the course.					
Online or web-based communication is an excellent platform for social interaction.					
I felt comfortable conversing through the online platforms.					
I felt comfortable participating in the course discussions.					
I felt comfortable interacting with other course participants.					
I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.					
Online discussions help me to develop a sense of collaboration.					

Cognitive Presence	1 Strongly Disagree	2	3	4	5 Strongly Agree

Problems posed by fellow students increased my interest in course issues.					
Course activities piqued my curiosity.					
I felt motivated to explore additional content related questions.					
I utilized a variety of information sources to explore problems posed in this course.					
Brainstorming and finding relevant information helped me resolve content related questions.					
Online discussions are valuable in helping me appreciate different perspectives.					
Combining new information helped me answer questions raised in course activities.					
Learning activities helped me construct explanations/solutions.					

Reflection on course content and discussions helped me understand fundamental concepts in this class.					
I can describe ways to test and apply the knowledge created in this course.					
I developed solutions to course problems that can be applied in practice.					
I can apply the knowledge created in this course to my work or other non-class related activities.					

Appendix I. AJRMSTE guidelines

Checklist: Submission file requirements

- A cover letter is required.
- Papers may be submitted in any standard format, including Word and LaTeX.
- Figures should be saved separately from the text. To assist you in preparing your paper, we provide formatting templates (see more information below).
- Separate files for figures and captions (if applicable)
- Separate files for tables and captions (if applicable)
- Supplemental online material (if applicable)

T&F manuscript layout guide

The Taylor & Francis manuscript layout guide will help you format your manuscript for submission to a Taylor & Francis or Routledge journal.

Formatting and templates

When writing your paper, you will need to format your journal article, ready for submission. To make this easier, Word templates are available for many of our journals, ready for you to download and apply to your research paper format.

Using keywords to write your title and abstract

Selecting the right keywords is the first step to creating an effective title and abstract, as well as helping the right readers find your article online.

Author details

Please ensure all listed authors meet the criteria. All authors of a manuscript should include their full name and affiliation on the cover page of the manuscript. Where available, please also include ORCID identifiers and social media handles (Facebook, Twitter or LinkedIn).

One author will need to be identified as the corresponding author, with their email address normally displayed in the article PDF (depending on the journal) and the online article. Authors' affiliations are the affiliations where the research was conducted. If any of the named co-authors moves affiliation during the peer-review

process, the new affiliation can be given as a footnote. Please note that no changes to affiliation can be made after your paper is accepted. Read more on authorship.

Word limits

Please include a word count when submitting your paper. Articles should be no more than 7000 words in length, including references and footnotes. Abstracts should not exceed 250-500 words and should not contain any footnotes or citations. Please also provide 5–8 keywords for indexing (only proper nouns should be capitalised).

Style requirements and reference guide

Please refer to these general style guidelines when preparing your paper, rather than any published articles or a sample copy.

Read more about Format-Free submissions and the use of special characters and mathematical scripts and equations.

References

The African Journal of Research in Mathematics, Science and Technology Education uses the American Psychological Association (APA), and papers should confirm strictly to the format in the latest revised manual of the reference style.

Disclosure statement

This is to acknowledge any financial or non-financial interest that has arisen from the direct applications of your research. If there are no relevant competing interests to declare please state this within the article, for example: *The authors report there are no competing interests to declare.* Further guidance on what is a conflict of interest and how to disclose it.

Peer review

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Understanding copyright for journals

Copyright is a type of intellectual property which protects certain sorts of original creative work, including academic articles. Copyright allows the creator of a work to decide whether, and under what conditions, their work may be used, published and distributed by others. As such, it governs how others can use, publish and distribute articles.

Images, tables, and figures

- Must be cited in the main text and in chronological order.
- Provided in a separate file to main paper (if applicable).
- Captions must include the matching number from the main text citation.
- If you did not create the figure or table yourself, you are required to obtained written permission to use it and provide Taylor & Francis the written permission upon request.
- Captions must include copyright holder details and state that permission to reproduce has been obtained.
- Acceptable file format.
- Acceptable figure quality.
- Tables must be editable.

More information is available on submitting electronic artwork and submitting tables.

Citations

If you are unsure of how to cite a specific source, you can read the important information about why and how you should cite sources in your article. These requirements apply to all journals published by Taylor & Francis Group.

ORCIDs

An ORCID ensures you and your research activities can be easily identified, meaning you get the credit for all the work you do. If you don't already have one, you can find out more details on how to set one up and start using it in your online submission to a Taylor & Francis or Routledge journal.

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You have the option to publish open access in this journal via our Open Select publishing program. Publishing open access means that your article will be free to access online immediately on publication, increasing the visibility, readership and impact of your research. Articles published Open Select with Taylor & Francis typically receive 45% more citations* and over 6 times as many downloads** compared to those that are not published Open Select.

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Please visit our Author Services website if you would like more information about our Open Select Program.

*Citations received up to 9th June 2021 for articles published in 2018-2022. Data obtained on 23rd August 2023, from Digital Science's Dimensions platform, available at https://app.dimensions.ai
**Usage in 2020-2022 for articles published in 2018-2022.

Ready to submit? Make sure you have:

- Checked your paper meets the word limit.
- Checked all essential elements of article present.
- Checked that all in-text citations have a corresponding Reference list entry.

- Styled your paper according to the journal guidance.
- Created a PDF version if submitting a LaTeX file.
- Not submitted the paper elsewhere.
- Checked you are compliant with Taylor & Francis Editorial Policies.

You can read more about this here.

Anonymisation

Check the requirements for your article type above and if an anonymous version is required to protect your identity during peer review, create a copy of your main file and then remove the following information:

- All author names
- All author affiliations
- All author email addresses
- All author ORCIDs and social media handles
- All author biographical notes
- Headers and footers that would reveal author identities
- Self-citation in the main text and references
- Acknowledgements
- Funding
- References to authors in figure and tables captions
- Clinical trial numbers and registration dates
- File identifiers that would reveal author identities

You also need to:

- Label the file as 'Without author details'
- If you are depositing data in a repository, make sure that it preserves anonymity.

More details on how to anonymise your file.

Submit

This journal uses Routledge's Submission Portal to manage the submission process. The Submission Portal allows you to see your submissions across Taylor & Francis' journal portfolio in one place. To submit your manuscript please click to submit your manuscript please click here.

If you are submitting in LaTeX, please convert the files to PDF beforehand (you will also need to upload your LaTeX source files with the PDF).

Please note that by submitting your paper you are agreeing to originality checks during the peer-review and production processes.

Appendix J. PiE journal guidelines

Perspectives in Education

ISSN: 0258-2236 e-ISSN: 2519-593X

Prof Jan Nieuwenhuis
Editor-in-chief
Nieuwenhuisfj@ufs.ac.za/perspectives@ufs.ac.za

Information for authors

Editorial Policy

Perspectives in Education (PiE) is a professional, peer-reviewed journal that encourages the submission of previously unpublished articles on contemporary educational issues. It represents a variety of cross-disciplinary interests, both theoretical and practical and seeks to stimulate debate on a wide range of topics. PiE is published biannually (June and December) and invites manuscripts employing innovative qualitative, quantitative and mixed methods and approaches including (but not limited to), ethnographic observation and interviewing, grounded theory, life history, case study, curriculum analysis and critique, policy studies, ethno-methodology, social and educational critique, phenomenology, deconstruction and genealogy.

Debates on epistemology, methodology or ethics, from a range of perspectives including post-positivism, interpretivism, constructivism, critical theory, feminism and post-modernism are also invited. PiE seeks to stimulate important dialogue and intellectual exchange on education and democratic transition with respect to schools, colleges, non-governmental organisations, universities and universities of technology in South Africa and beyond.

As the journal aims to make itself accessible to a wider reading community, it encourages authors to make their content accessible to a broad readership, including those who may not be familiar with the subject matter addressed. PiE challenges contributors to use innovative, provocative and creative ways of presenting and reporting their research.

Contributions **must be in English**, as the journal caters to an international audience.

Submission of articles

Articles are considered for publication provided that:

- The work is original.
- The work has not been published previously and is not under consideration for publication elsewhere.
- The author has secured the permission of all named co-authors, who have agreed on the order of the names for publication.
- An approved ethics board (a copy of the ethical clearance certificate/letter should accompany an article submission) has ethically cleared the research on which the article is based.

- The article has been language edited by a certified language practitioner (a copy of the letter from such a language practitioner should accompany an article submission).

  - The editor reserves the right to make editorial changes in any manuscript accepted for publication to enhance clarity or conformity with journal style.

The review process takes between 3 to 6 months to complete. Authors will be informed of the editor's decision on receipt of all of the reviewers' reports. **(Please note that it usually requires more time to review manuscripts submitted in the November–January period.)**

PiE invites submissions in the following categories:

Research articles

Contributors must submit typewritten manuscripts in MS Word format of between 5800–6400 words.

The following are considered when evaluating the suitability of a manuscript for publication in this section of PiE:

- The manuscript offers new, original insights or interpretations and the research is not merely a restatement of existing ideas and views.
- The manuscript makes a significant contribution to the field and extends the borders of educational debate.
- The manuscript is likely to arouse readers' interest and stimulate debate.
- The manuscript reflects sound scholarship and research design with appropriate, correctly interpreted references to other authors and works.
- The content of the manuscript is accessible to the broad readership of the education community and is not just addressed to specialists in the area.

Contributions in this section of the journal are subjected to our two-fold blind peer review process. The process is as follows:

- When articles are first received, they are scanned for compliance.
- If the article complies, it moves on to external double-blind peer review.
- When the article returns from external double-blind peer review, depending on the comments from the reviewers, it is sent to the author(s) with the option of reworking and resubmitting the article or it is accepted subject to minor changes.
- Authors will be informed if an article is rejected outright with reason(s) why it is not accepted.
- A reworked article is then re-evaluated to determine if it will be published. This is the editor-in-chief's decision and **the decision is final.**

The latter part of the journal, which is generally not subject to the peer review process, allows for the submission of the following:

Review articles

PiE invites succinct, critical, evaluative reviews of current literature on key topics in education. Reviews should provide a descriptive and evaluative summary and a brief

discussion of the significance of the work in the context of current theory and practice. In addition to the conventional literature review format, reviewers are encouraged to use alternative methods of representation such as critically engaging the author(s) in a dialogue on published books or articles.

General submission guidelines

- Please submit your article via our OJS platform that you can access at http://journals.ufs.ac.za/index.php/pie/index
  - If you have any technical difficulties, please email us on dsc@ufs.ac.za
- Name(s) of the author(s), title(s), and affiliation(s) should not be disclosed in the text.
- A separate document containing the author(s) details should accompany the article submission (a simple MS Word document will suffice).
- Please direct all enquiries to: perspectives@ufs.ac.za
- Tables and figures must be placed within their appropriate position in the article accompanied by the appropriate caption/heading.
- All scanned photographs/figures must be kept to a minimum quality level of 300 dpi. Diagrams should be inserted as images – preferably as jpeg or tiff files (**not drawn in MS Word using lines, shapes and arrows**).
- Tables and figures should be numbered consecutively and be accompanied by a brief heading for tables or caption for figures. Each table/figure must be referred to in the text.
- Tables should have text left aligned and numbers right aligned.
- Please use footnotes. Do not use endnotes.
- Articles must be typed in Arial font, 11pt, 1.5 spacing.
- Page margins should be 2.54cm.
- Headings should be bold and/or italics.
- Do not underline headings or text for emphasis.

Procedure for manuscripts accepted for publication

Publication fees of [redacted] per article published will be charged. Authors will be invoiced on acceptance of the article.

References

- References are cited in the text by the author(s) surname and the year of publication in brackets (Harvard method), separated by a comma: e.g. (Brown, 2001). Page references in the text should follow a comma after the date, e.g. (Brown, 2001: 69).
- If several articles by the same author and from the same year are cited, the letters a, b, c, etc. should be added after the year of publication e.g. (Brown, 2001a).

- In works by three authors, the surnames of all authors should be given in the first reference to such a work. In subsequent references to this work only the name of the first author is given, followed by the abbreviation *et al.*: e.g. (Ziv *et al.*, 2005).
- In works by four or more authors, the first citation is immediately truncated to the first author's surname and the abbreviation '*et al.*', with all the authors only being listed by their surnames in the reference list.
- For personal communications (oral or written) identify the person and indicate in brackets that it is personal communication, e.g. (M Smith, pers. comm.).

List of references

Only sources cited in the text are listed in the reference list, in alphabetical order. These should be presented as indicated in the following examples. Special attention should be paid to the required punctuation.

Journal articles:

Johnson, D.W. & Johnson, R.T. 2002. Gifted students illustrate co-operative learning. *Educational Leadership*, 50: 60-61.

Books:

Van Zyl, R. & Thomas, P.P. 2004. *Recent advances in classroom research*. New York: McGraw-Hill.

Chapters in books:

Dukzec, S. 2008. Gender issues. In: D Hicks & J Brown (Eds.). *Education for peace*. London: Routledge.

Unpublished theses or dissertations:

Squelch, J. 2001. Teacher training for multicultural education in a multicultural society. MEd dissertation. Pretoria: University of South Africa.

Anonymous newspaper references:

Citizen. 2006. Education for all, 22 March.

Personal communications:

Not retrievable and not listed.

Electronic references:

No author:
Violence and discipline problems in U.S. schools: 1999-2002. Available at http://www.nces.ed.gov/pubs98/violence/98030001.html [Accessed 3 June 2006].

Published under author's name:
Burbach, H. 2000. Violence and the public schools. Available at 4 http://www.people.Virginia.EDU/~rkb3b/Hal/SchoolViolence.html [Accessed 4 March 2001].

PiE checklist (before submitting an article)

- Article is between 5800–6400 words
- Article is typed in Arial, 11pt, 1.5 spacing, 2.54cm margins
- Article is referenced according to the Harvard referencing method
- Article is language edited (proof must be provided with article submission)
- Article is in MS Word format
- Article has an abstract
- Article has 4–6 keywords
- Article contains little to no self-referencing by the author(s)
- A separate document containing author details must accompany an article submission
- A clear statement regarding ethical clearance and the approval process for the research must be made

Appendix K. JTE guidelines

Submission Requirements

You must read and acknowledge that you've completed the requirements below before proceeding.

☐ The corresponding author is submitting an ORCID identifier in their author data and co-authors have been recommended to also provide an ORCID, as per the journal policy.

☐ All patients included within case reports or other article types in which an individual or a group of individuals can be identified have signed informed consent forms, or had had their legal guardian do so, giving permission to publish the submitted content under a CC-BY licence.

☐ Research has been approved by an appropriate ethics committee, with the name of the committee and reference number of approval included within the submitted file. Otherwise, a statement that ethics approval was not required has been added to the file.

☐ The manuscript fits the scope of JTE.

☐ The submission has not been previously published, in part or in whole, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor).

☐ All third-party-owned materials used have been identified with appropriate credit lines, and permission has been obtained from the copyright holder for all formats of the journal. Authors acknowledge their responsibility to gain all permissions prior to submission.

☐ All authors qualify as authors, as defined in the authorship guidelines, and have given permission to be listed on the submitted paper.

☐ Authors' names and affiliations have been temporarily removed from the manuscript to facilitate peer review. As per APA guidelines, relevant entries from the reference list have been temporarily replaced by "(citation omitted.)" The author's name does not appear in hidden metadata within the document submitted, such as in the Author field in Microsoft Word documents under File, Info, Related People.

☐ The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines. Every effort has been made to ensure that the submission is ready for peer review according to the journal's review policy. If submitting to a peer-reviewed section of the journal, the submitted files (including file properties) have been anonymised.

☐ Tables and figures

- Are referred to in the text and located in the body of the manuscript
- Are formatted according to the APA Publication Manual
- Are optimized to fit on a 4.5" x 6.75" page and black-and-white printing
- Do not include shading for graphs, but may include line patterns as fill
- Are editable using Microsoft products

☐ Separate files are submitted for each figure using jpg, tiff, gif, or png formats and a resolution of at least 300 dpi (600 dpi preferred).

☐ References

- Every reference cited in the text appears in the list of references, except those whose full reference listing appears in the note of a figure
- All references listed in the list of references have been cited in the text
- All reference listings follow the format specified in the APA Publication Manual
- The accuracy of each reference listing and any URL it contains has been checked

☐ Continuous line numbers are turned on. In Microsoft Word, this is done using Layout, Line Numbers, Continuous.

☐ Tables and figures are all cited in the main text and inserted within the text document. Tables and figures are optimized for portrayal on a 4.5" x 6.75" black and white page. Tables must be editable within Microsoft products.

☐ Fill patterns rather than shading was used in figures and tables to facilitate printing.

☐ High-resolution files for each figure are uploaded as supplementary files with a resolution of at least 300 dpi (600 dpi or above preferred) in one of the following formats: JPG, TIFF, GIF, or PNG.

☐ Figures and tables should be optimized for portrayal on a 4.5" x 6.75" black and white page. All figures and tables must fit and be legible within these size requirements without sacrificing legibility. Tables, line drawings, and graphs must be editable within Microsoft products and in vector rather than raster format when possible. Shading should not be used as a background for illustrations or graphs and within bar graphs; if needed, fill patterns consisting of lines should be used.

☐ If human subjects or animal research was conducted, a statement that the research has been approved by an appropriate review committee, with the name of the committee included within the submitted file. Otherwise, a statement that ethics approval was not required has been added to the file.