
THESIS SUBMISSION

A TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) PERSPECTIVE ON INTEGRATING EDUCATIONAL TECHNOLOGY (EdTech) FOR STUDENT TEACHERS

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Declaration

I, **Sybrand Johannes Coetzee (Student number: 199300597)**, declare that the thesis, **A TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) PERSPECTIVE ON INTEGRATING EDUCATIONAL TECHNOLOGY (EdTech) FOR STUDENT TEACHERS**, submitted for the qualification of Doctor of Philosophy 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 complete references.

I also declare that ethical clearance to conduct this study was received from the University of the Free State (UFS-HSD2022/2066).

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



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perspective on integrating educational technology (EdTech) for student
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Abstract

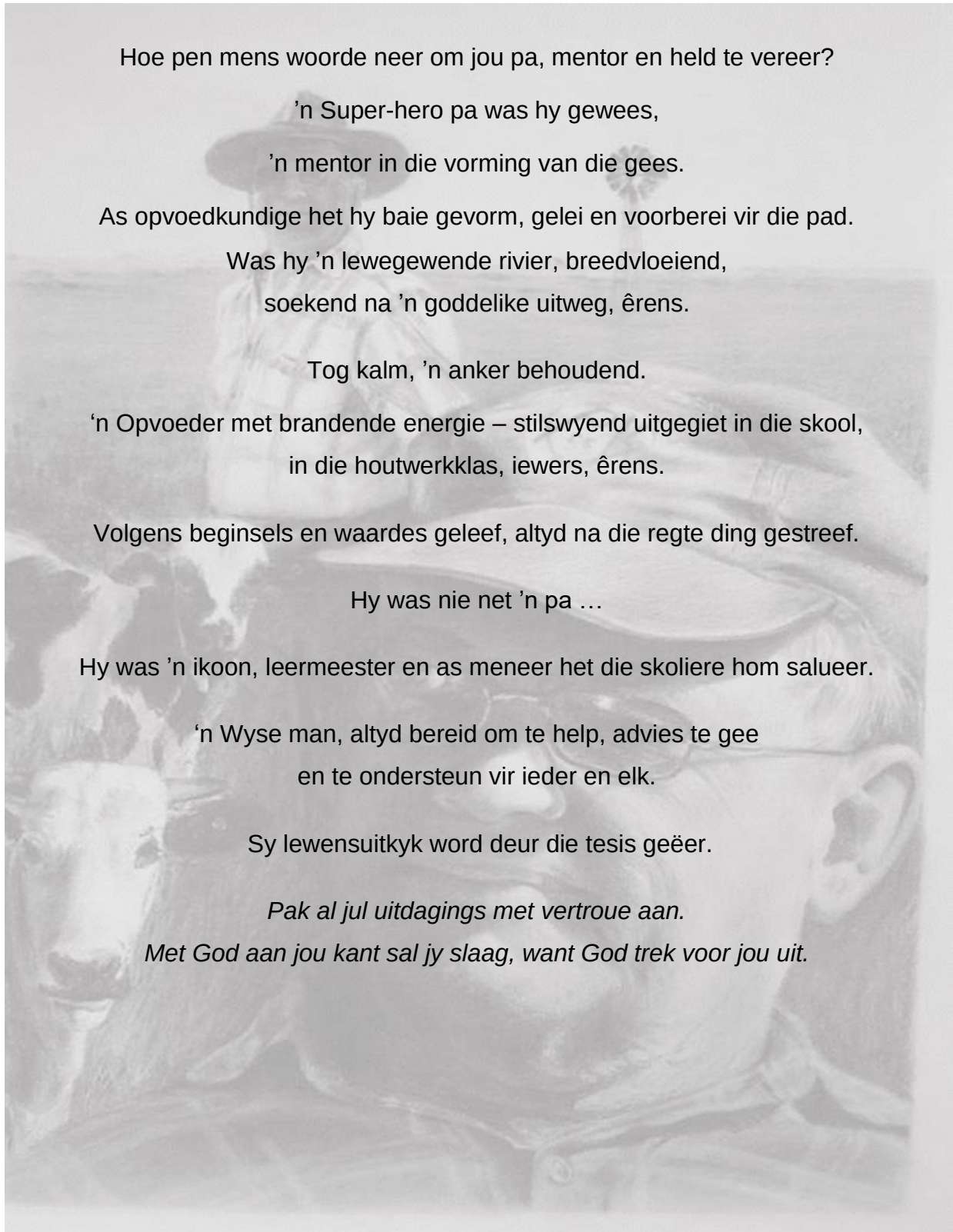
The rapid advancement of digital technologies is transforming higher education and leading to a shift from traditional teaching methods to online and blended learning environments. Research indicates that the effective integration of Educational Technology (EdTech) in subject-specific instruction necessitates a well-defined framework to support educators in applying the best use of digital tools for effective learning. This study utilised the technological pedagogical content knowledge (TPACK) model to examine the integration of educational technology (EdTech) in a first-year Engineering Graphics and Design (EGD) module (EGDC1614) during a 10-week intervention. The research explored the unique challenges and opportunities of EdTech and provides insights into how technology can create engaging, accessible and adaptive learning environments aligned with Education 4.0 principles. By embracing a pragmatic education design approach, the study investigated the practical outcomes of EdTech integration in a real-world education context. Data were collected through pre- and post-intervention questionnaires, a lecturer questionnaire and self-reflections that assessed the influence of EdTech tools such as computer-aided design (CAD) software and multimedia resources on student engagement and learning outcomes. The findings were validated by an expert panel for quality assurance purposes. Findings indicate that the EGD lecturer, positioned as a pivotal change agent in this approach, can leverage the TPACK model to effectively facilitate the integration of EdTech in EGD instruction. This strategic application of TPACK is expected to enhance both student understanding and engagement in the subject matter. However, challenges such as varying digital literacy levels and limited internet access highlight the need for targeted digital skills training and improved infrastructure. Blended learning models that combined digital tools with in-person instruction proved particularly effective in meeting student preferences for flexible, multimedia-rich learning experiences. The study emphasises the importance of structured EdTech implementation and adaptive learning environments for improving educational outcomes and preparing students for a digitalised workforce. It also advocates for digital equity by calling for support systems to address disparities in access and skills. Overall, the research underscores the necessity of resources that cater for diverse learning preferences and recommends further exploration into personalised and

adaptive learning technologies to enhance educational practices in the context of the Fourth Industrial Revolution.

Keywords: Engineering Graphics and Design (EGD); Educational Technology (EdTech); Student teachers; Technological Pedagogical and Content Knowledge (TPACK) model

Dedication

This thesis is dedicated to my late father, Stefanus Francois Coetzee.



Hoe pen mens woorde neer om jou pa, mentor en held te vereer?

'n Super-hero pa was hy gewees,

'n mentor in die vorming van die gees.

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soekend na 'n goddelike uitweg, êrens.

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'n Opvoeder met brandende energie – stilswyend uitgegiet in die skool,
in die houtwerkklas, iewers, êrens.

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en te ondersteun vir ieder en elk.

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List of abbreviations

4IR	Fourth Industrial Revolution
AI	Artificial intelligence
AR	Augmented reality
CAD	Computer-aided design
CK	Content knowledge
DBE	Department of Basic Education
EdTech	Educational technology
EGD	Engineering Graphics and Design
FET	Further Education and Training
HyFlex	hybrid-flexible
LMS	Learning management systems
MOOCS	Massive open online courses
NCS	National Curriculum Statement
PAT	Practical assessment task
PCK	Pedagogical content knowledge
PK	Pedagogical knowledge
STEM	Science, technology, engineering and mathematics
TCK	Technological content knowledge
TIM	Technology integration matrix
TK	Technological knowledge
TPK	Technological pedagogical knowledge
TPACK	Technological pedagogical content knowledge
VR	Virtual reality

CHAPTER 1

INTRODUCTION AND BACKGROUND TO THE PROBLEM

1.1 INTRODUCTION

Most residential universities have, over recent years, gradually integrated digital and electronic-mediated learning into their teaching practices (Black, 2010). The COVID-19 pandemic, however, catalysed a major shift, by pushing higher education institutions towards the rapid adoption of online and digital teaching methods, in an attempt to maintain educational continuity (AlQashouti et al., 2024). For many institutions, this transition meant shifting from traditional, face-to-face instruction to fully online learning environments, which underscored the need for accessible, high-quality education technology (EdTech) resources to support inclusive education (Bates, 2019).

In Engineering Graphics and Design (EGD) modules/programmes – for which the hands-on, practical nature of learning has traditionally emphasised in-person engagement – integrating EdTech has become essential (Western Cape Education Department, 2020). Platforms such as Blackboard and Moodle have become indispensable by enabling flexible access to course materials and interactive resources. This shift has sparked an interest in innovative teaching approaches, such as flipped classrooms, blended learning, problem-based learning and gamification, all of which align with the students' learning styles and their preferences for instruction methods that deliver active, personalised and collaborative learning experiences (see Chapter 3). Although face-to-face interaction remains invaluable, digital tools offer a means of sustaining engagement, particularly in hybrid or fully online formats.

The pandemic also inspired educators to re-evaluate instructional strategies to improve engagement by students amid the rapid technological advances characterising the Fourth Industrial Revolution (4IR) (Hendrick, 2023). Defined as the convergence of emerging technologies such as artificial intelligence (AI), biotechnologies and nanotechnology (Penprase, 2018), the 4IR has made integrating digital tools a priority for educators. The intersection of the 4IR with changes induced by the pandemic has been particularly pertinent for student teachers. As digital

natives, they possess elevated expectations of the integration of technology in their educational settings (refer to Chapters 2, 3 and 4 for further detail).

In light of these changes, technology educators in EGD must possess a balanced combination of digital expertise, pedagogical knowledge and content mastery, and the ability to create effective online learning experiences. This requirement aligns with the technological pedagogical content knowledge (TPACK) framework, which forms the foundation of this doctoral study. TPACK (Ait Ali et al., 2023) offers a model for integrating EdTech in ways that optimise teaching and learning, especially in practical components that benefit from interactive digital solutions (see Section 1.3).

This doctoral study explored, through the TPACK lens, the unique challenges and opportunities of integrating EdTech in online teaching for first-year EGD students, with the aim of providing insights into the way technology can foster more engaging, accessible and adaptive learning environments that are aligned with Education 4.0 trends.

1.2 RESEARCH PROBLEM

Literature perspectives emphasise that the push to implement effective online learning and teaching in higher education is shaped not only by the COVID-19 pandemic, but also by a need to re-evaluate instructional strategies so that they align with ongoing technological advancements (e.g., meeting student satisfaction as a key performance indicator for the evaluation of online degree programmes, as highlighted by Zhou and Rouse (2024) and the demands of the 4IR (Baber, 2023)). Today, when first-year students, who are digital natives who expect integrated, interactive and technology-enhanced learning, enter universities, traditional teaching models face increasing challenges to remain relevant (see Chapter 3). These evolving factors underscore three core influences in higher education:

- i) The need for alternative, remote teaching methods after the disruptions caused by COVID-19;
- ii) The rapid technological integration of the 4IR; and
- iii) The changing and diverse student profile, which causes a need for innovative programme delivery approaches (Rapanta et al., 2021).

In this context, technology education lecturers, particularly those working with future student teachers, face the critical question of how to effectively integrate EdTech and to create meaningful, engaging and relevant learning experiences. The demands of the “new normal” in higher education, shaped by COVID-19 and accelerated by the 4IR, call for a balanced approach that embraces new technologies while responding to first-year student teachers’ learning style and instruction method preferences (see Chapter 3).

This doctoral study, grounded in the TPACK framework (see Section 1.3 and Chapter 2), explored and evaluated methods to enhance the relevance of online learning and teaching in technology education. Specifically, this study examined the EGD module at the university that was involved in this study, by focusing on how EdTech can be leveraged to meet the education needs of first-year students. By reflecting on teaching practices through the knowledge components of TPACK, the study conceptualised the lecturer’s role as a mediator and facilitator, with the aim of providing adaptable, future-ready instructional approaches in technology education.

1.3 THEORETICAL FRAMEWORK: TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

The rapid expansion of digital technologies transformed both professional and recreational activities and has, more recently, had a substantial influence on higher education. This transformation created significant opportunities to enhance teaching and learning through technology and to foster personalised learning, increased engagement and interactive platforms (Araya, 2023). The integration of digital technologies in education – also higher education – stimulates the development of essential skills, including collaboration, creativity and digital literacy, which are skills that are fundamental in today’s education landscape (Marr, 2022).

In the context of the post-pandemic shifts in higher education and the demands of Education 4.0 (Öztürk, Türker & Kerse, 2024), the TPACK framework provides a relevant conceptual foundation for integrating EdTech in instructional practices, particularly for the EGD module for first-year student teachers (refer to Figure 1.1). The TPACK framework offers a comprehensive lens by which technology education lecturers can navigate the challenges of delivering content in an online environment

to Generation Z students, who are digital natives who are accustomed to interactive, digitally immersive experiences.

By addressing the multifaceted nature of teacher knowledge required for effective technology integration, TPACK identifies three primary knowledge domains: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK) and emphasises the intersections between these domains, namely pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK). Together, these domains allow for a nuanced approach to structuring content and instructional methods that align with digital environments. This is especially relevant in light of 4IR advancements and first-year student learning styles and online instruction method preferences, which underscores the need for adaptable teaching practices that can harness the potential of digital technology, while mitigating its limitations (Evans et al., 2016).

The TPACK model, therefore, is central to the focus this study on online EdTech integration in the EGD module, as it connects theoretical insights with classroom practice and allows for a structured approach to defining both *what* to teach (CK) and *how* to teach it effectively in an online setting (PK). Through TPACK, this research will explore how technology education lecturers can use EdTech (i.e., open-source applications and digital tools) to create an engaging, accessible and relevant learning experience for first-year student teachers in the online environment.

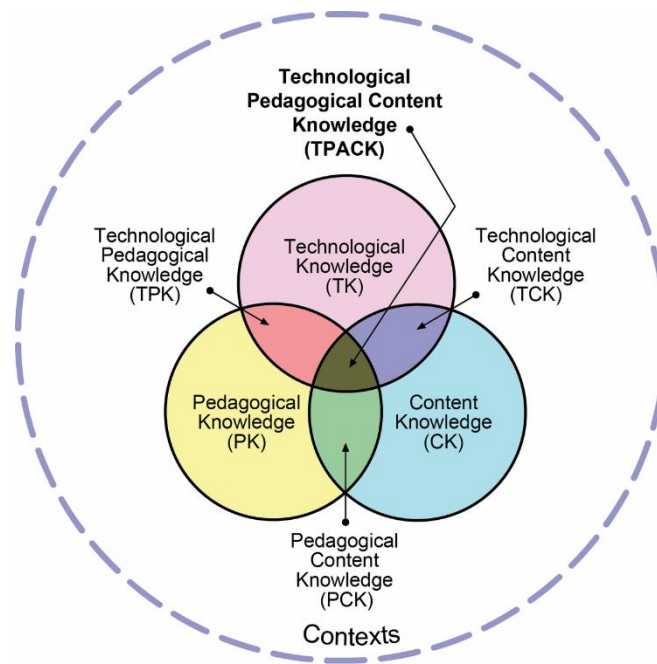


Figure 1.1: The TPACK framework and its knowledge components
(Ait Ali et al., 2023)

By navigating the complexities of teaching with digital technology, the TPACK framework (Figure 1.1) addresses the diverse and context-specific nature of the teacher knowledge necessary for effective technology integration (Ait Ali et al., 2023). The framework not only identifies the three essential knowledge domains – CK, PK and TK – but also emphasises the interactions between these domains, that is PCK, TCK and TPK. This interconnected structure enables educators to apply and adapt digital tools in ways that respond to the specific needs of their subject matter and the unique characteristics and preferences of their first-year student teachers (Gupta & Bhattacharya, 2021).

The utility of TPACK lies in its ability to bridge theory and practice by guiding educators on both what to teach (CK) and how to teach it in a digital environment (PK) (Purba et al., 2021). For example, integrating open-source applications and digital resources in teaching not only enhances accessibility but also aligns with Generation Z’s learning preferences and the goals of Education 4.0. Thus, as Mishra et al. (2009) and Pamuk (2012) explain, the TPACK model provides a practical and theoretical lens for understanding how digital technologies can support more interactive and meaningful learning experiences, especially for technology education.

This study leveraged TPACK to inform the online delivery of the EGD module, by focusing on developing digital competencies in prospective technology education lecturers (Niess, 2011). Through the structured approach of TPACK, the research aimed to establish the best way to apply EdTech tools in ways that are pedagogically sound, contextually relevant and technologically feasible, to ultimately foster an adaptive and engaging learning environment for first-year EGD student teachers.

1.4 RESEARCH QUESTIONS, AIM AND OBJECTIVES

As a lecturer in technology education, I constantly engage in reflection on and conducting research in my practice. After examining the stated problem (Section 1.2), I present the main and subsidiary questions of this doctoral study.

1.4.1 Main research question

How can a technology education lecturer use a TPACK perspective to integrate EdTech for EGD first-year student teachers' online learning and teaching?

To address this main question, five subsidiary questions were formulated.

1.4.2 Subsidiary research questions

1. How can integrating EdTech in first-year EGD online learning and teaching be conceptualised through a TPACK perspective? (Chapter 2)
2. How do diverse students' learning styles and instruction method preferences influence online learning and teaching? (Chapter 3)
3. What are the critical trends in Education 4.0 for applying EdTech in EGD online learning and teaching? (Chapter 4)
4. How can EdTech in online learning and teaching of first-year EGD student teachers (after being introduced) meet the needs and Education 4.0? (Chapter 6)
5. What guidelines can be proposed for integrating EdTech in the online learning and teaching of first-year EGD student teachers through a TPACK lens? (Chapter 7)

These questions confirm that this higher education study aims *to investigate how EdTech can be integrated into online learning and teaching for first-year EGD student*

teachers through a TPACK lens. To achieve the above aim and address the research questions (see Sections 1.4.1 and 1.4.2), the following objectives will be pursued.

1.4.3 Objectives

The objectives of the study were to:

1. Determine, with a literature review, how to conceptualise the integration of EdTech in first-year EGD online learning and teaching through a TPACK perspective.
2. Establish, with a literature review, how diverse students' learning styles and instruction method preferences influence online learning and teaching.
3. Through a literature review, determine what critical Education 4.0 trends are required for applying EdTech in EGD online learning and teaching.
4. Through a 10-week intervention and critical self-reflection, determine how EdTech in online learning and teaching of first-year EGD student teachers meet the needs of Education 4.0.
5. Determine, based on a 10-week intervention, critical self-reflection and a panel of experts, proposed guidelines for EGD lecturers for integrating EdTech in the online learning and teaching of first-year EGD student teachers through TPACK.

The research started with a detailed observation of the trends involved in using digital technology for learning and teaching. It then shifted focus to using free of charge online resources and applications to teach a specific group of students at a higher education institution.

The epistemological position of this research had a pragmatic philosophical underpinning, which was beneficial, as it could stimulate change (Biesta, 2008). The stance of this research was predominantly concrete, with abstract elements referring to learning and learning experiences. The research reflected on my own practice.

The data were analysed by applying the elements of TPACK as a theoretical framework.

1.5 RESEARCH METHODOLOGY

According to the problem statement (see Section 1.2), the literature refers to three intertwined forces in higher education, namely COVID-19, the 4IR and changing student demographics. Given these forces, technology education lecturers face the critical question of how to effectively respond in a way that ensures higher education remains relevant and effective for the students of today. To address the research problem, a qualitative approach was employed, complemented by quantitative elements (see Section 1.5.1). The use of a pragmatic education research design (see Section 1.5.2) was appropriate, as this design facilitates a deeper exploration of practical teaching and learning outcomes in a real-world education context. Thus, this higher education case study strategy (see Section 1.5.3) aimed *to investigate how EdTech can be integrated into online learning and teaching for first-year EGD student teachers* (i.e., in the EGDC1614 module) *through a TPACK lens* (see Section 1.4.2). Because the researcher was also the lecturer of the EGD module, the position of the research and reflexivity was clarified (see Section 1.5.4).

1.5.1 Qualitative approach complemented by quantitative elements

This study employed an interdisciplinary, qualitative research approach (with an element of quantitative) to examine the integration of EdTech in the teaching and learning of first-year EGD students, with the aim of proposing guidelines for education technology lecturers. The advantage of this approach is that the researcher can incorporate viewpoints from both education technology and the realm of the higher education field. The primary aim of this interdisciplinary method is to address real-world, complex issues and to offer diverse viewpoints on problem-solving (Choi & Pak, 2006). In this case, the focus was on improving the integration of EdTech teaching and learning of first-year EGD student teachers in education technology.

1.5.2 Aligning the research focus with research design and paradigm

Aligning the research focus (see Sections 1.2 and 1.5) with the pragmatic education research design and pragmatic paradigm is crucial to ensure coherence and clarity throughout the study (see Section 5.2). The use of a pragmatic education research design was appropriate for this case, as it facilitates a deeper exploration of practical teaching and learning outcomes (i.e., integrating EdTech) in real-world education

contexts (e.g., the EGD module). Additionally, it addresses the aim of this study (see Section 1.4), as explained in Section 1.5.

Pragmatic research also attempts to ascertain the meaning of intellectual concepts by referring to practical consequences that reflect a practical experimental outlook in a real-world situation (Holtrop & Glasgow, 2020) through inquiry. As justification for the pragmatic paradigm used for this research, an inductive approach was applied, to gain insight into how, when and why change works in practice (Dede et al., 2004, p. 160; Ramanadhan et al., 2021), with special emphasis on integrating EdTech in the teaching and learning of EGD by first-year student teachers and satisfying the demands of online teaching in the “new normal”, as the 4IR and Education 4.0 demand. Additionally, by adopting an inductive approach, this research focused on gathering data directly from the EGD classroom environment. This qualitative insight was crucial in understanding how EdTech can be effectively integrated into HyFlex (hybrid-flexible) teaching and learning, as well as determining the conditions under which these changes are most effective.

Thus, this research embraced a pragmatic epistemological underpinning (see Section 5.2 and Table 5.1), which emphasised the practical implications of knowledge and sought to understand how digital technology can effect positive change in educational practices. This aligns with Biesta’s (2008) perspective that education should facilitate change rather than merely impart knowledge. The stance of this research was predominantly concrete, with abstract elements referring to first-year EGD learning and teaching experiences by reflecting on EdTech integration in the EGD module. This also aligns with the TPACK (see Section 1.3 and Chapter 2) framework – it is not tied to a single paradigm but is rooted in a pragmatic paradigm because of its focus on the practical integration of TK, PK and CK for effective teaching. TPACK, based on a pragmatic paradigm, emphasises real-world applications and the practical use of technology in teaching (i.e., online teaching in this study). Also, TPACK values solutions that work in specific contexts, thereby aligning with pragmatism's emphasis on outcomes and functionality. Additionally, TPACK aligns, to some extent, with constructivist principles because it supports the idea of teachers as facilitators who construct meaningful learning experiences by leveraging the interplay of TK, PK and CK. However, its core approach to adaptability and utility situates it primarily in a pragmatic framework.

1.5.3 Case study strategy and method

In research, case studies are characterised by both their distinctiveness and their potential for confusion. The term case study can be ambiguous, because it is applied in various contexts. In this higher education case study, it is not only a method/technique/process of data collection, but also a research strategy (Priya, 2021). This use aligns with Creswell's (2014, p. 241) clear and comprehensive definition of case study strategy, which states that the "researcher explores in depth a programme, event, activity, process, or one or more individuals". The case (for this study, first-year student teachers in the EGD module) is defined by specific timeframes and activities (for this study, a 10-week period in the first semester of 2024), during which researchers gathered comprehensive information through diverse data collection methods (Section 1.5.5.3).

The following key case study attributes, as listed by Priya (2021), are relevant to this study. A case study involves a detailed study of the concerned unit of analysis within its natural setting, which can be an individual, a family, a household, a community, an organisation, an event or even a decision. For an in-depth study, case study research methodology gives a researcher leeway to use any method of data collection that suits their purpose (provided the method is feasible and ethical – see Section 1.5.5.3). For example, this "single, exploratory case study" thoroughly examined the integration of EdTech (i.e., the problem) in an EGD module tailored for first-year student teachers at a South African higher education institution. By examining current trends in digital technology use in educational contexts, the research intended to inform the development of effective pedagogical strategies that enhance technology education. By employing a case study strategy, the research investigated a specific instance of module delivery over a 10-week intervention period (i.e., the process – see Section 1.5.5.1 and Chapter 5); I focused on the way students and educators engaged with EdTech in EGD. The intervention was structured to provide insights into module effectiveness and the dynamics between students' digital experiences and pedagogical strategies, based on the technology integration matrix (TIM) (Shaw et al., 2018) – see full details in Section 1.3.3.1.

1.5.3.1 Intervention overview

The 10-week intervention followed a structured education framework that is based on the TIM (Shaw et al., 2018). The TIM facilitated the progressive integration of EdTech in the EGD module in the first academic semester of 2024. It evolved through five distinct levels of digital engagement (for a full description, see Chapter 5 and Appendix G), by transitioning from passive consumption to more advanced and autonomous applications of technology. The 10-week intervention proposed merging traditional and digital learning strategies to enhance students' competencies in EGD.

1.5.3.2 Research population and sampling

a) Target population

The research population of this study was technology education students and lecturers at a South African higher education institution (the University of the Free State). Students and lecturers of the Department of Mathematics, Natural Sciences and technology education were included in this study.

b) Sampling

In this higher education study, a total population sampling technique was applied, which is a type of purposive sampling technique that involves examining the entire first-year EGD population (i.e., the total population in the BEd programme specialising in the Further Education and Training [FET] phase) that possessed a particular set of characteristics (e.g., involvement in the EGDC1614 module – both students (n=19) and lecturers (n=2)). Thus, the inclusion criteria stipulated all registered University of the Free State first-year EGD students in 2024.

1.5.3.3 Data collection

As explained in Sections 1.5.1 and 1.5.3, this was a mainly qualitative approach with quantitative elements that used diverse data sets; it was considered the most feasible and ethical instrument for this in-depth single, exploratory case study (see Section 1.5.3.2) on the integration of EdTech in the teaching and learning of first-year EGD student teachers during a 10-week intervention (see Section 1.5.3.1).

a) Student questionnaires

Two questionnaires (see Appendices D and E) were distributed to 19 first-year EGD student teachers to gauge their experiences, preferences and engagement (before

and after the intervention was introduced) with the integration of EdTech in teaching and learning of EGD. The questionnaires comprised open-ended and structured Likert scale questions to elicit in-depth qualitative responses that provided insights into the perceptions and challenges faced by these students. The responses to these questions were thematically grouped and analysed. Quantitative data elements, such as closed-ended questions, helped to quantify student engagement levels, satisfaction with EdTech integration and perceived learning outcomes. This data provided a broader context for the qualitative findings.

b) Lecturer questionnaire and self-reflection of praxis

The qualitative data collected with a third questionnaire was completed by lecturers and questions related to EdTech integration of teaching and learning EGD. Self-reflection data provided by the researcher emphasises the lecturer's experiences, adaptations and learning derived before and after the 10-week intervention and from interactions with students (Appendices F and G).

1.5.3.4 Data analysis, interpreting and reporting

As explained in Section 1.5.2, an inductive approach to analysis was followed in this qualitative study, which involved two student questionnaires (Appendices D and E) and one lecturer questionnaire (Appendix F). Google Sheets was used to create the basic layout for each question in the questionnaires. For the qualitative thematic analysis, I utilised the Qualitative Thematic Analysis Assistant. For the quantitative data analysis, Data Analysis & Report AI were used to process the datasets and to identify patterns and generate statistical insights.

An inductive approach to analysis was followed with the aid of the above-mentioned software, and it took the following steps:

- Familiarisation with data;
- Initial coding;
- Search for themes;
- Review and refine themes;
- Define and name themes; and

- Interpret and compile a report (Maree, 2019; McMillan & Schumacher, 2014).

The purpose of the analysis was to provide explanations for a phenomenon (McMillan & Schumacher, 2014), namely EdTech integration in teaching and learning of the EGD module during a 10-week intervention. I worked in an ethically responsible way by being non-biased, accurate and honest throughout the data analysis, interpretation and reporting by applying verifiable methods such as thick/detailed descriptions and presenting data in tables. To determine and ensure the quality of this qualitative research with its quantitative elements, I applied triangulation and took measures to ensure the trustworthiness, credibility, dependability, confirmability and transferability of the study (the way these quality aspects were evaluated and applied will be described in Chapter 5).

1.6 CONCEPTUALISATION OF KEY CONCEPTS

The following terms are clarified because of their particular interpretation in the context of this study.

1.6.1 Educational technology

EdTech is a term used nationally and abroad that encompasses various tools, applications and resources designed to enhance teaching and learning via digital means. According to the 2023 Global Education Monitoring Report of UNESCO (2023: 15), **EdTech** refers to the "utilisation of digital tools, resources, and processes to improve the quality of teaching and learning". The definition encompasses a wide range of activities, such as imparting knowledge, facilitating learning, overseeing educational institutions and ensuring the availability of educational materials. Also, the International Technology and Engineering Educators Association (2023) describes EdTech as the use of technology to improve education by supporting teachers and students in the learning process by involving various digital tools and methodologies to make the teaching and learning process more engaging and effective.

In South Africa, the Department of Basic Education (DBE) (2022) explains that EdTech involves using digital tools to enhance teaching and learning at various levels of education. This approach to teaching and learning goes beyond merely deploying hardware and software; it includes leveraging technology to address education

challenges unique to South Africa. McCubbin et al. (2022) explain that EdTech is the systematic and integrated use of digital tools and resources to enhance teaching and learning. These tools and resources include computers, mobile devices, learning management systems (LMS) and the internet, with the aim of improving education outcomes and accessibility for diverse student populations. According to this research, EdTech refers specifically to using digital resources and online applications. Digital resources include devices such as computers, tablets, interactive whiteboards and projectors in education settings. Digital applications encompass educational apps, LMSs and other software that support learning activities and administrative tasks. For the purpose of this study, EdTech refers to both resources and applications for prospective integration in a HyFlex teaching and learning environment that caters for first-year students and Education 4.0.

1.6.2 Engineering Graphic and Design

Today, EGD is a key subject in technology education, which has become increasingly significant because it equips individuals with crucial engineering and design skills (EGD Learning, 2023). Thus, EGD aims to equip students with the skills to effectively create and convey technical design ideas through graphical and digital techniques, to offer solutions to engineering and design problems. The value of EGD in the world of work relates to careers in manufacturing, engineering and technology in particular (Zhang et al., 2022).

1.6.3 Student teachers

In this doctoral study, student teachers refer to first-year EGD preservice teachers.

1.6.4 Theoretical framework: Technological pedagogical content knowledge

As explained in Section 1.3, this doctoral study justified TPACK as the most relevant and beneficial theoretical framework (also see Section 1.7).

1.6.5 HyFlex

Literature conceptualises HyFlex as a dynamic approach to accommodating diverse learning preferences and contexts (Narayan et al., 2021). In this study, the term

HyFlex refers to a teaching and learning model that combines face-to-face and online learning, thereby offering students the flexibility to choose how they attend each lesson session. Students can participate in-person, join virtually in real-time, or access recordings and materials asynchronously at their convenience (Barr & Luo, 2024).

1.7 VALUE OF THE STUDY

Integrating EdTech resources into EGD through the TPACK lens offering could be pivotal for advancing higher education praxis. TPACK research prepares future educators by equipping them with essential skills to effectively utilise digital tools in modern classrooms (Pamuk, 2012). Also, TPACK insights have proven instrumental in maintaining education continuity (Jandrić, 2020), enriching educational practices, supporting continuous professional growth and enabling educators to adapt to technological advancements (Koehler et al., 2020). This adaptability improves teaching practices and contributes to resilient education systems that are capable of meeting evolving challenges.

1.8 ETHICS CONSIDERATIONS

Upholding ethical practices is vital throughout the research process and reflects a commitment beyond mere adherence to institutional guidelines (ethics are discussed in detail in Section 5.11). First, I adhered to the ethical clearance guidelines for researchers of the University of the Free State (No. UFS-HSD2022/2066; Appendix J). Second, ethical considerations that were critical in this study emphasised obtaining informed consent from all first-year EGD participants and the lecturer responsible for the second-year module (Appendix A), ensuring their understanding of the study aims and procedures. Confidentiality and anonymity were upheld to protect their identities (Western Cape Education Department, 2020) through the use of pseudonyms when reporting data. The privacy of data and findings were safeguarded through password protection and secure storage in locked cabinets (see Section 5.10). To ensure the validity and reliability of the data and its analysis, rigorous methods of statistical analysis were employed, alongside thorough coding and recoding of the qualitative data (see Section 5.10). In this mainly qualitative research, which was complemented with quantitative elements, data triangulation was applied through multiple

perspectives (i.e., first-year EGD student teachers and reflections of lecturers) to enhance the credibility and validity of study findings (Jackson, 2021). By collecting information from different angles, researchers aim to enhance the comprehensiveness and reliability of their interpretations; additional quality measures in this study will be discussed in Section 5.9.

1.9 RESEARCHER'S REFLEXIVITY, POSITIONALITY AND POWER RELATIONSHIPS

This study requires a positionality statement in which the researcher articulates the position, biases, perspectives and background that could influence the research process and its outcomes.

I was the principal investigator of a research cohort that examined challenges faced by first-year students when integrating EdTech in the EGD module at the South African case study university. I have 25 years of teaching experience, of which I focused on Technology for 25 years and also, for the last four years, on this EGD module. I also have a decade of professional experience as a technology education lecturer. I brought a diverse perspective to this study. I recognised that my personal biases and positionality may influence the research process, including question formulation and data interpretation.

Additionally, researcher reflexivity, positionality and power relationships are critical concepts in qualitative research, as they involve the researcher's ongoing awareness and articulation of their influence on the study (see Chapter 5). To counteract bias, I prioritised transparency and reflexivity, engaged in self-reflection, sought feedback from colleagues and my supervisor and utilised rigorous theoretical research frameworks (i.e., TPACK and the TIM) and appropriate methodologies. This statement underscores my commitment to conducting the study ethically (see Section 1.7 and Chapter 5) and sensitively, while actively working to minimise potential biases.

1.10 CONCLUSION

This study explored the integration of EdTech into EGD modules for first-year student teachers through the TPACK framework, by aligning with the learning preferences of students and the demands of Education 4.0 (see Sections 1.1–1.3). The findings affirm

that digital tools such as Blackboard, Moodle and computer-aided drawing and design (CAD) software significantly enhance both engagement and comprehension in EGD by bridging theoretical and practical learning needs and providing flexible, self-directed and interactive learning environments.

The study emphasis on TPACK integration reflects a commitment to meeting the digital expectations of first-year student teachers, who increasingly rely on adaptive, collaborative and multimodal learning experiences. The rapid shift to online learning, which was catalysed by the COVID-19 pandemic, along with the influence of the 4IR, underscores the importance of integrating adaptable and personalised digital tools in education.

Ultimately, this doctoral research provides insight into creating engaging, accessible and adaptive learning environments through a balanced application of the TPACK framework. These insights contribute to a more nuanced understanding of how technology can support effective online teaching, particularly in hands-on EGD contexts, while preparing educators to leverage digital solutions for inclusive and effective education in a rapidly evolving digital landscape.

In brief, this chapter introduced the TPACK theoretical framework (Section 1.3) and elaborated on the research questions, aims and objectives that guided this study (Section 1.4). In addition, the chapter provided an overview of the research methodology (Section 1.5), discussed the key concepts that are central to this study (Section 1.6), and underscored the significance of this research (Section 1.7).

Chapter 2 provides a foundational exploration of critical themes in technology education, particularly in EGD, to establish the context for integrating EdTech through the TPACK framework. It examines current digital resources, emerging Education 4.0 trends and practical applications to set the stage to answer the first subsidiary research question, namely, How can integrating EdTech in first-year EGD online learning and teaching be conceptualised through a TPACK perspective? Chapter 2 aims to equip educators with the insight needed to effectively incorporate digital tools and adapt to the advancing educational landscape.

CHAPTER 2

CONCEPTUALISING THE INTEGRATION OF EDUCATIONAL TECHNOLOGY IN ENGINEERING AND GRAPHIC DESIGN: A TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE PERSPECTIVE

2.1 INTRODUCTION

As outlined in Chapter 1, EdTech has significantly transformed the professional landscape and the dynamics of teaching and learning. Rapid advancements in EdTech, compounded by the need for remote instruction during the COVID-19 pandemic, intensified the demand for educators to integrate contemporary digital tools into their pedagogical practices. It is important to examine the interplay between educators' knowledge and its application in the contexts of educators' classrooms in the framework of incorporating EdTech in educational settings. Considering this context, the TPACK lens (see Figure 2.1) was identified as the most suitable framework (Sections 1.3 and 1.7) for investigating the integration and application of EdTech in EGD's learning and teaching processes.

This chapter focuses on the TPACK framework (see Section 2.3) for technology education (see Section 2.2) and the insights it offers for enhancing teaching effectiveness and integrating EdTech into classroom practices, particularly in EGD, through TPACK, as the theoretical framework.

This literature review focuses on the following aspects: conceptualising technology education as an umbrella term (see Section 2.2), with a particular emphasis on EGD and related competencies (see Section 2.2.1), evaluating the integration of EdTech resources through the TPACK framework (see-Section 2.3), and examining the levels of EdTech integration (see Section 2.4).

2.2 TECHNOLOGY EDUCATION

As indicated in Section 1.6.2, technology education is a comprehensive and all-encompassing study of several fields, including engineering, design, computer

science and information technology. Technology education aims to provide students with the knowledge and skills they need to function effectively in a world increasingly dominated by technology (Department of Basic Education, 2023) and become active and productive members of society.

The idea of technology education has changed dramatically over the years, and has transcended its historical emphasis on traditional crafts and skills-based disciplines such as metalworking and woodworking, to include design components and universal technological literacy. Research of Morrison-Love, quoted by Pujiastuti and Haryadi, (2023), reports that, in contrast to its roots in the industrial arts, technology education now focuses more on helping students improve their problem-solving abilities through technical design. Thus, the concept of technology education has expanded to include design elements and universal technical literacy and extends beyond traditional crafts and skills development areas (International Technology and Engineering Educators Association, 2024).

To educate students for involvement in a technology-driven world, technology education programmes emphasise critical thinking, creativity and lifelong learning, in addition to the manipulation of materials, such as wood and metal. This change emphasises how important it is to incorporate design thinking in the classroom, so that students can successfully navigate the hurdles posed by contemporary technology and make wise judgements (International Technology and Engineering Educators Association, 2024). This shift places a strong emphasis on using technical design to develop critical thinking, creativity and problem-solving skills – all of which are crucial for surviving in a technologically advanced society. These days, the focus is on lifelong learning and the application of technology knowledge, facilitating students to use cutting-edge tools and procedures to address problems in the real world (Collier-Reed & Ingerman, 2021; ITEEA, 2020).

In South Africa, technology education has changed dramatically; today it integrates problem-solving, critical thinking and social responsibility. The development of programmes such as the Coding and Robotics curriculum places strong emphasis on improving technical literacy of and teamwork among students, to prepare them for a digital economy. However, issues such as the digital divide and a shortage of resources still make the expansion of technology education difficult. Notwithstanding

these obstacles, the curriculum aims to use education to address socioeconomic issues and promote sustainable development and lifelong learning (Chomunorwa et al., 2023).

These arguments confirm that design is acknowledged as a fundamental component of technology education, in South Africa and abroad, with special emphasis on the importance of promoting creativity and problem-solving abilities, particularly in disciplines such as engineering and design education. Therefore, design and technology education is essential for fostering creativity, critical thinking and sustainable problem-solving (Janse van Rensburg & Rauscher, 2021). Designers should be able to sketch initial ideas on paper and create working drawings that provide sufficient detail for the task (e.g., in EGD, see Section 2.2.1). Practical skills for implementing effective solutions and working safely using appropriate tools and techniques must be emphasised. Lastly, designers must be able to present their solutions convincingly and effectively to clients or customers (Department of Basic Education, 2023).

2.2.1 EGD as part of technology education

Today, EGD is a subject (presented at school) and module (presented in higher education) that is becoming increasingly important as technological advancements continue to shape our world. Both these terms (subject and module) can be used interchangeably in the context of this study. In Technology Education/Design in Technology (see Section 1.6.3), both school and higher education focus on creating and communicating technical design concepts. EGD also involves using graphical and digital techniques to develop and present solutions to engineering and design problems. Thus, a critical component of technology education is providing students with the necessary skills to succeed in engineering and design, through which designers execute ideas using drawings. Carefully developed engineering drawings are utilised to interact with components and device makers (Oude Molen Technical High School, 2023).

Although EGD is a subject taught in South African schools under the National Curriculum Statement (NCS), and in higher education, this study focuses only on the latter. The EGD curriculum covers principles that range from foundational to advanced. For example, it includes freehand sketching, orthographic projections, pictorial

drawing techniques (oblique, isometric, perspective), and detailed assembly drawings (Oude Molen Technical High School, 2023). Thus, students learn to make various working drawings, such as civil drawings (e.g., foundations, house plans), electrical diagrams and mechanical drawings. Advanced topics cover loci, vector geometry (forces, moments) and cam drawings. Additionally, digital tools such OnShape and EdrawMax are integrated to enhance technical design. In brief, the module prepares students for achieving technical proficiency in engineering by focusing on problem-solving, design principles and practical applications (Faculty of Education, University of the Free State, 2024). This approach is closely aligned with the TPACK framework (see Section 2.3), which advocates for integrating technological, pedagogical and CK. By equipping students with both the technical skills and the conceptual understanding necessary to do effective problem-solving and design, the module (EGDC1614) exemplifies how TPACK can be applied to enhance learning outcomes in EGD.

2.3 TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

It is important to identify the types of knowledge teachers require to integrate technology effectively in their teaching. Thus, TPACK (see Figure 2.1) is regarded as a valuable tool for addressing the complexity, diversity and situational nature of teacher knowledge. TPACK also eases the conceptual process of applying TK and manifesting it in the higher education context. Thus, TPACK refers to teachers' understanding of how, when, and where to use technology while assisting students to gain more information and skills in specific curriculum areas through effective pedagogical techniques (Niess, 2011). For example, TPACK enables a dynamic phenomenon such as the convergence of educational technology to be investigated thoroughly by offering analytical and development-ready alternatives for teaching and learning (Section 1.7). Therefore, TPACK (Figure 2.2) encourages students, teachers, and researchers to move past overly simplistic approaches that treat technology as an “add-on”, instead of highlighting the linkages between digital technology, content and pedagogy in educational settings (Guntari, 2023; Stapf & Martin, 2019) as an integrated approach.

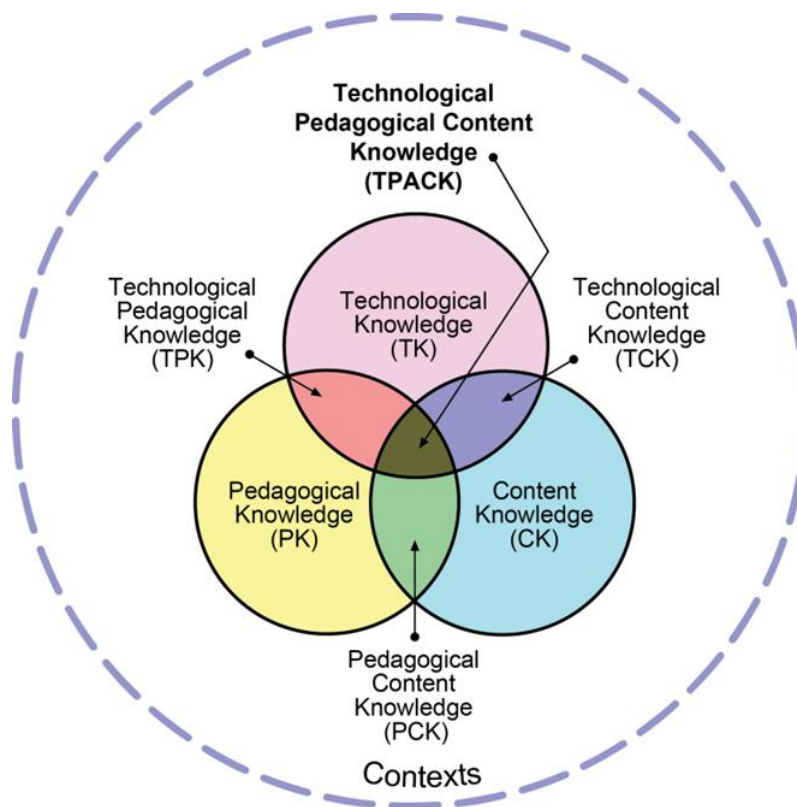


**Figure 2.1: The TPACK framework and its knowledge components
(Ait Ali et al., 2023)**

The TPACK framework offers a valuable strategy for lecturers who need assistance to incorporate EdTech resources into their teaching and learning. Kurt (2017) highlights the significance of three different kinds of knowledge in TPACK: CK (see Section 2.3.1), PK (see Section 2.3.2) and TK (see Section 2.3.3). Thus, the TPACK framework emphasises that integrating EdTech resources successfully must be founded on the interaction between content and pedagogy by differentiating between these knowledge domains. This aspect is crucial because, to improve students' learning experiences, EdTech resources must support pedagogy and material delivery (see Section 5.4, Table 5.1).

The TPACK framework also facilitates the integration and interaction of three distinct types of knowledge: CK, PK and TK. According to Luo and Zou (2022), TK delineates the specific relationships and interactions between technological tools and specific pedagogical practices, referred to as TPK. Similarly, PCK provides insight into the connections between specific learning goals and pedagogical strategies (Guntari, 2023). TCK clarifies the intersections between technologies and learning objectives

further. Consequently, the TPACK framework empowers educators to identify effective pedagogical strategies and technologies that align with their educational goals (Kurt, 2017). The various types of knowledge encompassed in the TPACK framework are discussed in detail in the next subsections.

2.3.1 Content knowledge

The knowledge of the subject matter that educators are expected to teach or acquire is called CK. Worldwide, including in the South African higher education context, CK includes comprehending the facts, theories, laws, customs and procedures necessary to create such information (Kurt, 2017).

Additionally, educators must grasp the nature of knowledge and inquiry in various fields (Asamoah, 2019). In this study, CK refers to the case study university's EGD module (see Appendix I for curriculum and outcomes-related details on the EGDC1614 module). CK knowledge on its own is not sufficient for academic success, but it remains essential to allow teachers to convey subject matter to students and address their needs effectively. Thus, a conceptualisation of EdTech that can be applied to support the scholarly teaching and learning of a module is imperative (see Sections 2.4.3 and 4.4).

2.3.1.1 International perspective on CK for EGD

The EGD subject/module is an academic discipline that imparts internationally recognised principles with broad application in both academic and technical realms. The EGD curriculum is designed to develop basic problem-solving, communication, and technical drawing abilities needed for diverse fields, including mechanical, civil and electrical engineering. To provide students with the skills necessary for success in both academic research and professional professions, EGD focuses on developing a comprehensive understanding of design processes, technical knowledge and practical application (Faculty of Education, University of the Free State, 2024).

Globally, the concepts taught in EGD include accuracy in technical drawing and the capacity to decipher complicated visual information required in industries such as engineering design, manufacturing and architecture. These abilities are essential for creating models and drawings and making precise depictions of technical ideas that can be used in practical settings (Indovance, 2023).

Integrating EdTech and CK in TPACK in South African higher education requires a thorough understanding of the EGD curriculum. For example, the EGD curriculum in South Africa places a strong emphasis on helping students develop their technical drawing, design thinking and spatial visualisation skills. Thus, if EGD students know how to use online applications and resources, it can assist these students to learn essential concepts and acquire skills. Consequently, teachers must be competent at integrating relevant EdTech and how they fit into the more extensive EGD curriculum (Department of Basic Education, 2023). Additionally, EGD teachers (Department of Basic Education, 2023) must be conversant with the assessment standards and the South African NCS for constructive alignment purposes.

2.3.1.2 Case study university perspective on CK for EGD

EGD places considerable emphasis on instructing students in the fundamental knowledge and a range of drawing techniques and skills to enable them to effectively interpret and generate drawings in the specific contexts of mechanical technology, civil technology, and electrical technology (Department of Basic Education, 2021; EGD Learning, 2024).

In the EGD domain, there is also a distinct emphasis on equipping students with specific foundational knowledge, including essential concepts and skills crucial for technical drawing. This knowledge covers standard drawing conventions, spatial visualisation for interpreting and creating 3D objects and understanding geometry and precise measurements. Additionally, students master projection techniques such as orthographic and isometric views, which are essential for accurately representing objects in fields such as mechanical, civil and electrical technology (Department of Basic Education, 2021). This knowledge serves as a cornerstone for students to build their understanding of the underlying principles governing EGD. Concurrently, EGD cultivates a diverse skill set that encompasses various drawing techniques. Through systematic instruction and practice, learners develop the necessary proficiencies to interpret and produce drawings accurately and effectively (Department of Basic Education, 2021).

In South African higher education, EGD covers a broad range of topics that serve as the cornerstone of the discipline. The ideas and methods of drawing, as well as the application of CAD technology, are all covered in these topics. The primary topics

covered in EGD are general drawing principles that apply to all technological drawings, freehand drawing techniques, instrument drawing methods, first and third-angle orthographic projections, descriptive and solid geometry concepts, mechanical working drawing principles, civil working drawing principles, isometric drawing techniques, perspective drawing methods, electrical diagram representation, interpenetrations and developments in design, the study of design, and CAD (Department of Basic Education, 2021; Faculty of Education, NWU, 2024; Faculty of Education, University of the Free State, 2024).

Research (Gao & Mager, 2013; Kurt, 2017) confirms that, if lecturers desire to teach effectively with digital applications and resources, they need a deep understanding of the subject matter (in this study, of EGD). This deep understanding of the subject matter includes understanding the skills and concepts (as highlighted in the previous paragraph) that students need to learn and the best methods of teaching these skills and concepts. Thus, in addition to knowledge of EGD subject matter, it is also essential that lecturers have a strong understanding of the digital resources that are available and how to use them to teach effectively to support student learning. Understanding the strengths and weaknesses of different digital resources and selecting the most appropriate ones for the learning goals are essential.

Overall, CK knowledge is vital for the effective and scholarly teaching of EGD in the South African higher education context. Thus, continuing professional development is essential for staying current with EGD CK and EdTech changes.

2.3.2 Pedagogical knowledge

A thorough understanding of the techniques, procedures and methods of teaching and learning, as well as the overarching goals, values and objectives of higher education, is referred to as PK. All facets of student learning, classroom management, lesson design, execution and student evaluation are supported by this general kind of knowledge (Stapf & Martin, 2019). Thus, PK is a broad category of knowledge that informs and directs effective teaching methods. For example, techniques or methods that are appropriate for classroom instruction, the features and demands of the target audience and ways of evaluating student understanding are essential knowledge domains of PK. Thus, an academic with a thorough understanding of pedagogy

(i.e., PK) can support students' knowledge construction and skills development and cultivate good attitudes towards learning (Ait Ali et al., 2023; Kurt, 2017).

Additionally, applying cognitive, social and developmental theories of learning in the classroom is a crucial component of pedagogical expertise (i.e., PK). Educators can adapt their instructional strategies to meet the various learning demands of their learners/students if they understand these notions thoroughly (Mishra et al., 2009). By applying these learning theories, educators can design a welcoming and fair learning environment that accepts students from various backgrounds and with different learning preferences and skills. Educators must acquire pedagogical expertise to provide effective teaching and learning experiences, encourage academic performance and support learners' overall development (Guntari, 2023; Luo & Zou, 2022). To assist student learning effectively and to foster a good learning environment, teachers must have PK.

Research also confirms that creating lessons that successfully combine EdTech with PK and CK is essential (Kimmons et al., 2015; Guntari, 2023), in this study, with special reference to teaching EGD PK. To facilitate effective learning, PK in EGD uses a variety of teaching tactics, including project-based learning, peer collaboration and formative assessments (Department of Basic Education, 2023). To facilitate learning effectively, there exist diverse teaching and learning approaches in higher education institutions that require lecturers to find a balance between online learning and teaching, blended and face-to-face learning.

Johnson et al. (2022) define HyFlex as a teaching and learning method in which students can choose their mode of learning on any given day. They can choose between attending their classes in-person, synchronously online and asynchronously only. Hybrid learning is a strategy applied to achieve the intended learning objectives by combining in-person (synchronous) and online (asynchronous) encounters. Every student in a hybrid course engages in the same mix of face-to-face and virtual learning activities. In turn, the "flexible" feature of HyFlex allows students to interact with the course material in the way that suits them best, session by session. Three ways to participate in HyFlex courses are in-person synchronous sessions, video conferences (such as Zoom), or asynchronous learning with coursework. No matter how they choose to participate, all students in a HyFlex lesson have access to the same

materials and meetings, whether they engage in-person or virtually, during or after lessons, to ensure they all achieve the same learning goals (Columbia Center for Teaching and Learning, 2020).

The flexibility of HyFlex in allowing students to choose their mode of participation mirrors the adaptability inherent in PK, which emphasises adjusting teaching methods to suit different learners' cognitive, social and developmental requirements. Thus, integrating HyFlex learning with PK ensures educators can create inclusive and effective learning environments while meeting educational goals. The terms “flexible” and “hybrid/blended” are combined in HyFlex learning (Columbia Center for Teaching and Learning, 2020).

2.3.3 Technology knowledge

TK concerns essential teaching technologies such as books, videos and chalkboards, and more advanced technologies such as the internet, online applications and resources (Asamoah, 2019). The concept of TK encompasses not only knowledge, but also a range of skills that pertain to using specific technologies in teaching and learning. Thus, TPACK is a framework that emphasises integrating technology, pedagogy and CK in teaching.

In addition, TK involves proficiency in utilising EdTech, which includes a sound understanding of operating systems and computer hardware and the ability to use various software tools, such as word processors, spreadsheets, browsers and email applications (Bwalya, 2024). Teachers must be well versed in the EdTech they employ in their classrooms and able to navigate and resolve any technical issues that might crop up, in addition to being able to choose the best tools and platforms that relate to their particular teaching goals and learning outcomes (Ng et al., 2023).

Teachers must also know the pedagogical ramifications of using technological tools and resources in their lessons. This includes understanding how to create and present lessons utilising EdTech effectively and developing instructional strategies, test questions and feedback systems promoting student learning. The acquisition and mastery of such skills and knowledge are critical for educators seeking to integrate technology into their pedagogical practices effectively and to ensure that learners are

equipped with the requisite digital competencies for success in the contemporary world (Guntari, 2023).

Lastly, TPACK technology expertise includes successfully integrating technological tools and resources to produce relevant learning experiences for students. This includes understanding how to modify teaching methods in response to the requirements and input of the students, as well as how to employ technology to improve student learning (Kurt, 2017). Thus, TPACK and continual professional development are essential for staying abreast of the most recent technological advancements and pedagogical methods for successfully integrating online applications and resources in teaching (Guntari, 2023).

In the context of the topic of EGD in South Africa, TK plays a critical role in the TPACK framework. In the context of EGD, TK refers to educators' knowledge of and competence for using technologies to improve teaching and learning processes in the discipline. This comprises, but is not restricted to, graphic design programmes, 3D modelling tools and prototyping technologies. EGD teachers must be thoroughly aware of their capabilities and functionalities to effectively use these tools to help teach and learn EGD principles.

Additionally, EGD teachers with good TK skills must be proficient at choosing and utilising the best technology resources and tools to target learning objectives and meet the various needs of their learners. For example, teachers need to understand computer hardware, operating systems, and software tools if they are to use technology effectively in the classroom.

Integrating technology through TK is even more important in the South African setting, where the subject of EGD plays a significant role in fostering critical thinking, problem-solving and design skills (Department of Basic Education, 2023). EGD teachers can engage learners in interactive and collaborative learning experiences, provide them with the ability to visualise and simulate design concepts, and support the development of technical skills essential for the discipline by utilising technology properly. Overall, TK within the TPACK framework equips EGD student teachers in South Africa with the knowledge, abilities and self-assurance to incorporate appropriate technologies in their teaching strategies, thereby fostering higher-order thinking abilities, increasing student engagement, and preparing students for the

technology demands in the field of EGD. The discussion elaborated now on how to apply TPACK to the online learning and teaching of EGD.

2.4 EXPLORING PEDAGOGICAL KNOWLEDGE FOR TEACHING ENGINEERING GRAPHICS AND DESIGN

Understanding PK is essential for effectively teaching complex subjects such as EGD. Professional educators need to excel in the subject matter while also grasping the best teaching techniques and approaches suited for this specialised area. This investigation into PK for EGD aims to reveal ways educators can blend theoretical and practical methods to improve student learning results, by emphasising the cultivation of skills such as technical drawing, spatial visualisation and problem-solving in engineering settings.

2.4.1 Pedagogical knowledge for teaching EGD

Pedagogical expertise for EGD is critical for generating practical and meaningful learning experiences for students in this specialised subject area. EGD comprises a variety of skills, such as technical drawing, design, and visualisation, that aspiring engineers and designers need.

PK refers to an educator's proficiency in both the science and the art of teaching and encompasses the skills required to engage students and foster effective learning experiences (Guerriero, 2017). In the realm of engineering EGD, PK pertains to the specific expertise and methods instructors employ to teach the subject successfully. This involves integrating engineering graphics principles, such as drawing standards and spatial visualisation, orthographic projection, isometric and perspective drawing, problem-solving and design thinking, CAD and digital literacy and contextual understanding with tailored teaching methods for EGD to enable educators to foster engaging and interactive learning spaces.

The literature review identifies several critical factors that educators must understand to implement teaching and learning for PK effectively. Table 2.1 provides an overview of four authors who discuss these essential factors for PK in teaching and learning.

Table 2.1: Comparison of key factors of PK by various authors

Key factors	Shulman (1987)	Guerriero (2017); Grossman et al. (2019)	Darling-Hammond et al. (2020)	König et al. (2021)
General pedagogical knowledge	Principles for managing and organising classrooms across contexts		General PK model that integrates pedagogy and psychology	Centred on student learning with a task-based framework for teacher competency
CK	Deep understanding of the subject matter being taught			
PCK	Blending content expertise with teaching strategies to engage students	Amalgamation of content and pedagogy to tailor teaching to student needs (based on Shulman's PCK)		
Curriculum knowledge	Familiarity with subject-specific curricula and materials			
Knowledge of learners and their characteristics	Understanding student diversity and learning needs			
Knowledge of educational contexts	Awareness of the broader school environment, governance and culture			
Knowledge of educational ends, purposes, values, and philosophical foundations	Understanding broader education goals, values and their philosophical foundations			
Classroom management			Classroom management	Classroom management
Instructional methods			Instructional methods	
Assessment strategies			Assessment strategies	
Learning processes			Learning processes	

Key factors	Shulman (1987)	Guerriero (2017); Grossman et al. (2019)	Darling-Hammond et al. (2020)	König et al. (2021)
Comprehension of individual student traits		Awareness of student misconceptions	Understanding individual student traits	
Knowledge of content and students (including misconceptions)		Familiarity with instructional strategies		
Knowledge of content and teaching				
Organising lessons				Organising lessons
Fostering motivation				Fostering motivation
Adapting to various teaching methods				Adapting to various teaching methods
Evaluating student performance				Evaluating student performance

Based on the definition of PK and the various models listed in Table 2.1, the following model is formulated for PK in the EGD context. In the context of teaching EGD, PK refers to educators' specialised understanding, abilities and competence to competently prepare and promote learning in this subject area. It includes a wide range of critical components that work together to ensure the successful transmission of EGD content and the development of students' knowledge and abilities in EGD.

Key factors of PK for teaching EGD were discussed in the following subsections.

2.4.1.1 From curriculum to lesson plan

Transitioning from the curriculum to a well-structured lesson plan requires a comprehensive understanding of EGD content. This understanding entails aligning the curriculum with education standards and learning objectives, carefully selecting relevant topics and organising the content logically to ensure progressive learning. For successful content delivery, it also requires proficiency in technical drawing, CAD, architectural drawing, mechanical design and other related areas (see Appendix I).

An annual teaching plan is tailored explicitly for lecturers who intend to teach CAD; however, it places the responsibility for planning on each EGD lecturer, who is tasked with selecting appropriate resource materials, engaging activities and practical assessment tasks for inclusion in the annual teaching plan (Department of Basic Education, 2021). The plan must provide indicative minimum timeframes (duration) for each topic and the maximum number of lecturing days allocated for each topic. All assessment tasks related to each topic must be completed within the designated weeks or days. The need for flexibility is acknowledged (Department of Basic Education, 2011), and alterations to the sequences or allocated week(s)/days of the plan are permitted (see Appendix I).

2.4.1.2 Instructional strategies

To effectively teach EGD concepts, it is essential to have a comprehensive understanding of various instructional strategies. These strategies encompass employing visual aids, hands-on activities, project-based learning and problem-solving approaches to actively engage students in the learning process (Department of Basic Education, 2021; Jain et al., 2018). For an EGD lecturer, adapting teaching methods is crucial to accommodate diverse learning styles and personalised learning experiences (Eden et al., 2024), instruction mode preferences and individual needs and paces (Abulibdeh et al., 2024; Eden et al., 2024) of students in the EGD classroom (see Section 3.2.2), thereby promoting inclusivity and accessibility.

Additionally, proficiency in utilising relevant software and technology associated with EGD, such as CAD software, 3D modelling tools and multimedia resources, is essential for enhancing online learning and teaching experiences. By leveraging these tools, instructors can provide a more immersive and interactive learning environment (Department of Basic Education, 2021). Technology integration transcends the basic introduction of devices and software in classrooms; it requires a strategic alignment of technological tools with pedagogical objectives, with the aim of cultivating digital literacy, critical thinking and creativity in students through thoughtfully mediated activities (Eden et al., 2024). In the South African context, effective technology integration is not only essential for enhancing educational outcomes, but also for addressing the digital divide and advancing equity in the education system.

Moreover, connecting EGD concepts to real-world applications and industry practices is paramount. This practice helps students understand the practical relevance of their learning and fosters their preparedness for potential careers in engineering and design (Department of Basic Education, 2021). By adopting inclusive strategies and fostering collaboration among stakeholders, educational institutions can harness the full potential of technology to create more equitable and enriching learning environments for all students.

In brief, a well-rounded EGD lecturer will possess familiarity with diverse instructional strategies and be adept at adjusting their teaching approaches to cater to the unique needs and paces of students. They should also demonstrate proficiency in relevant software and technology and effectively link EGD concepts to real-world applications for practical understanding and future professional success (Department of Basic Education, 2021). In this doctoral study, I integrated these diverse instructional strategies (face-to-face, blended, HyFlex, synchronous and asynchronous) and relevant software and technology (e.g., EdTech such as PowerPoint, Onshape, Interactive learning material, websites and Blackboard) aspects in a 10-week intervention (see Appendix H).

2.4.1.3 Assessment and evaluation

EGD is a knowledge and application/skill-based subject. Thus, competence is required of lecturers to develop appropriate assessment methods and tools to evaluate students' understanding and application of EGD concepts. Traditional assessment methods, such as performance-based assessments, design projects and practical exams, must be adapted to the online environment to ensure they remain effective (Department of Basic Education, 2021).

Incorporating EdTech into EGD also requires using technology-based assessments to evaluate students' understanding and application of concepts. A systematic review by UNESCO (2022) explored the use of technology-based assessments and their influence on education systems. The review highlights the potential of these assessments to provide immediate feedback, enhance student engagement, and offer personalised learning experiences. Implementing technology-based assessments in EGD can facilitate regular feedback and support the developmental process essential for the subject (Alrababah & Molnár, 2021).

However, to ensure that the assessment of the tasks contributes successfully to the EGD teaching and learning process, it is imperative that assessment tasks, whether formal or informal, are assessed within one week of being submitted (Department of Basic Education, 2021).

2.4.1.4 Classroom management

In a HyFlex teaching and learning environment for EGD, classroom management must effectively combine the needs of in-person and online teaching to provide a unified and engaging learning experience. Effective management in EGD involves setting clear expectations, promoting student participation, and meeting individual learning needs (Western Cape Education Department, 2020). This dual-modality approach relies on physical classroom resources and digital tools for remote learning, which are essential for promoting inclusivity and accessibility (Eden et al., 2024).

In the physical EGD classroom, essential resources are important for productive learning. These include secure storage for materials and equipment, ample space for medium-to-large desks that can fit A3-size drawing boards and tools such as set squares, rulers and computers with CAD software. Visual aids such as blackboards, whiteboards and projectors support in-person demonstrations to help students understand drawing techniques better (Department of Basic Education, 2021). Lockable storage is also provided for teachers' and students' resources to ensure safety and organisation.

On the other hand, the online part of a HyFlex EGD environment requires digital resources that replicate classroom tools (Hattie & Zierer, 2020). Students need access to CAD software and virtual drawing tools to practice and complete projects from home. Digital platforms with screen-sharing features and virtual whiteboards allow for real-time demonstrations and can be recorded for later use (Hattie & Zierer, 2020; Western Cape Education Department, 2020). Cloud-based storage solutions give students and teachers secure access to assignments by enabling them to submit and review work from anywhere.

To keep students engaged in both settings, lecturers should promote participation through structured activities, virtual breakout rooms for collaboration and regular feedback sessions (Hattie & Zierer, 2020). In a HyFlex environment, flexible access to

digital resources, enhanced visualisation tools and expandable storage options streamline the learning process and allow students to work on assignments independently (Western Cape Education Department, 2020).

While online EGD teaching requires thoughtful adaptation of traditional classroom management principles, it opens up new opportunities for flexibility, access to digital resources and enhanced visualisation, which can foster engaging, interactive and immersive learning environments and student engagement and motivation (Eden et al. 2024). This HyFlex approach integrates the advantages of both physical and digital resources to create a flexible and supportive learning environment that aligns with EGD principles and promotes student success.

2.4.1.5 Professional development

Educators must commit to continuous professional development to stay updated with the latest trends, research and advancements in EGD education. This development includes attending workshops and conferences and engaging in collaborative networks with fellow educators (Department of Basic Education, 2011). Professional development programmes should also be designed to help educators develop proficiency in using technology tools and resources, integrating technology into their curriculum and addressing the diverse learning needs of students (Yurtseven Avci et al., 2020). Doing so will enable EGD lecturers to create a comprehensive understanding of the subject, enhance student teachers' technical skills and grow their creativity and problem-solving talents in engineering and design by possessing good PK.

2.4.2 Implementation of EdTech to enhance the role of EGD PK

The successful implementation of digital resources and online applications relies heavily on the role of PK. PK encompasses understanding effective teaching methods, learning theories and instructional strategies, combined with a deep awareness of the best way to harness technology to support and enrich the learning process (Eden et al. 2024). Educators play a crucial role in bridging the gap between technological proficiency and pedagogical expertise, thereby ensuring that the potential benefits of digital applications and resources are realised fully in educational settings.

In their article, “The Education Integration of Digital Technologies preCovid-19: Lessons for Teacher Education”, Valverde-Berrocso et al. (2021) explain that a lecturer can follow a series of approaches for using digital resources and online applications. The first approach is collaborative (see Appendix H, Weeks 1–4), in which digital competence is developed in students through synchronous and asynchronous knowledge-building technologies, including online forums, video conferencing systems, the use of social networks and Web 2.0 tools (online collaborative documents), blogs or specific software for collaborative learning. These activities enrich collaboration through the participation of others (students, teachers, trainers, specialists and researchers) in different geographical contexts.

With the metacognitive approach (see Appendix H, Week 5), a space is created for students to reflect on the didactic action by expressing and analysing their thoughts, behaviours and/or the consequences of their professional practices in any situation involving digital technologies. The metacognitive approach uses digital resources and online applications to guide students to become aware of their learning strategies and consciously regulate their cognitive processes (Valverde-Berrocso et al., 2021). It encourages students to reflect on their understanding of the subject matter, monitor their progress and adjust their learning strategies.

The mixed-learning method (see Appendix H, Weeks 8–10) integrates in-class and out-of-class activities to cultivate digital teaching and learning skills through diverse online resources and digital applications. This approach not only equips students to navigate various learning platforms effectively, but also develops proficiency in employing these platforms for teaching purposes. By implementing a mixed-learning approach, educators can establish a dynamic and flexible learning environment that caters for distinct learning preferences, encourages active participation and nurtures a more profound comprehension of the subject matter (Valverde-Berrocso et al., 2021).

Valverde-Berrocso et al. (2021) identify the modelling-based approach (see Appendix H, Weeks 7–9) as the fourth instructional strategy. With this approach, lecturers assume the roles of tutors or mentors to encourage particular practices and present diverse perspectives on the teaching-learning process. This is achieved through deliberate demonstrations of specific action guidelines and teaching

strategies about the seamless integration of digital technologies, which can effectively influence classroom practices.

The last approach is the authentic learning approach (see Appendix H, Weeks 8–10), in which the teaching and learning activities represent real-life situations (Valverde-Berrocso et al., 2021). When using digital resources and online applications, the authentic learning approach seeks to connect classroom activities with authentic tasks and problems that mirror challenges encountered in the real world. This approach aims to engage students actively in the learning process by promoting problem-solving, critical thinking and decision-making skills. The authentic learning approach offers a student-centred and dynamic learning environment that uses digital resources and online applications. Bridging the gap between theory and practice equips students with relevant skills and competencies needed to thrive in real-world settings, while fostering a deeper understanding of and appreciation for the subject matter (Valverde-Berrocso et al., 2021).

In the digital age, the significance of PK in effectively implementing digital applications and resources is critical to producing meaningful and engaging learning experiences. Educators with a solid pedagogical foundation and technical expertise with digital technologies can create dynamic and adaptive learning environments that cater for various learning styles and develop more profound knowledge. PK enables instructors to harness technology as a strong tool for improving student learning outcomes, by thoughtfully integrating digital resources and teaching methodologies and considering student needs. Educators may maximise the transformative potential of digital apps and resources by regularly reflecting on and modifying their teaching techniques, thereby equipping students with the required skills and knowledge to flourish in a quickly expanding technology context.

2.4.3 Levels of integration: PK needed for implementing digital applications and resources in education

Technology has become essential in modern education and has significantly transformed the teaching and learning landscape. Nevertheless, educators often struggle to integrate technology effectively into their practices as classrooms adapt to the digital age. This examination of technology integration levels aims to reveal the

potential of technology to enrich education and equip students for 21st-century challenges.

As proposed by the TIM (Shaw et al., 2018), the five levels of technology integration (see Figure 2.2) in the curriculum provide a comprehensive framework for understanding how technology is used in educational settings. Building on this foundation, I developed a 10-week strategy to guide the effective integration of technology in line with these levels, ensuring that each stage aligns with pedagogical goals and enhances student learning outcomes (see Section 5.3 and Appendix H).

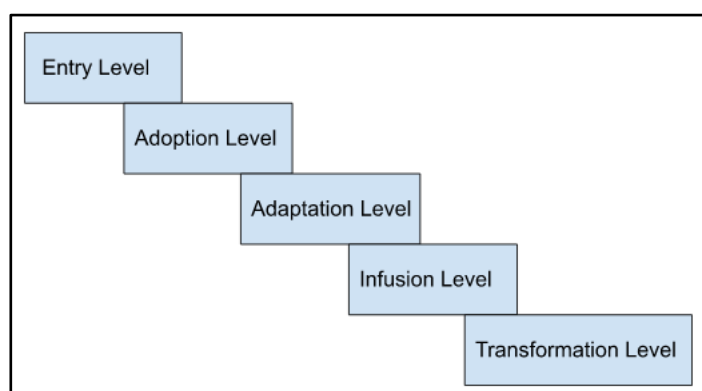


Figure 2.2: Technology integration matrix

The five levels of technology integration in the curriculum offer a structured approach to understanding how educators incorporate technology in educational settings. Integration starts at the entry level with primary technology use, moves up to the adoption level for more intentional integration, the adaptation level for restructuring instruction, the infusion level, where technology becomes integral and, finally, the Transformation level, where technology empowers students. This framework enables teachers to progressively enhance their teaching methods and empowers students with vital digital skills to achieve success in the modern world (Shaw et al., 2018). Additionally, the five levels are categorised according to the five characteristics of meaningful learning: active learning, collaborative learning, constructive learning, authentic learning and goal-directed learning (Shaw et al., 2018).

2.4.3.1 Entry level

At the **entry level** (see Appendix H, Weeks 1 and 2), lecturers and students (i.e., student teachers in this study) realise that technology creates new possibilities for

teaching and learning. The lecturer introduces digital resources and online applications to deliver content to students as *active learning*. Students receive information passively from the lecturer through instructional videos they view on a website or an online application for drill and practice activities. Mostly, the lecturer is the only person who actively uses technology, which can include presentation software to support the delivery of a lecture. Overall, the students' use of technology is regulated and limited (Abucayon et al., 2016).

Instead of engaging in collaborative learning at the entry level, students primarily work alone. The lecturer directs students to work alone on technology-related tasks. Constructive learning takes place through only the lecturer presenting content and information to all the students via digital resources and online applications. In authentic learning, the lecturer utilises available resources, whether in physical or digital formats, such as textbooks, to support teaching and learning following a predetermined curriculum that may not directly relate to real-world scenarios. As a result, students use technology to complete assigned activities that are often disconnected from real-world applications beyond the immediate instructional environment (Shaw et al., 2018). Goal-directed learning occurs through the lecturer giving clear direction to the students and monitoring the completion of tasks step-by-step. Students may receive the goals, directions, guidance and feedback via the lecturer's digital resources and online applications.

2.4.3.2 Adoption level

At the **adoption level** (see Appendix H, Weeks 3 and 4), the lecturer assumes the role of guiding students in the conventional and procedural application of technology tools (Shaw et al., 2018). At this level, the lecturer is responsible for selecting appropriate digital resources and online applications and determining the timing and manner of their implementation. Consequently, students' exposure to various technology tools may remain confined to tasks requiring procedural comprehension and execution.

Active learning occurs primarily under the guidance of the lecturer, who exercises control over the selection and nature of digital resources and online applications employed by the students. The lecturer could structure the students' progress through a project and ensure that each individual completes every step in a uniform sequence

using the same tool. Despite the increased level of activity exhibited by students, compared to the entry level, the lecturer maintains significant regulation over the learning activities. Consequently, due to this instructional control, students utilise digital resources and online applications conventionally (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

During collaborative learning, students could employ collaborative tools such as email in conventional ways. However, these opportunities for collaborative engagement through technology remain restricted and are not consistently integrated into their learning experiences. The instructor continues to guide students in the conventional use of technology tools for collaborative tasks, and occasionally facilitating groupwork as collaborative technology tools become accessible for use. Students engage in constructive learning by using online resources and digital applications to build on past knowledge and generate meaning. The lecturer provides students with opportunities to use traditional methods of technology to gain information and experience. The students develop meaning about the connections between existing knowledge and new learning, but the teacher makes the technology choices (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

In this stage, authentic learning occurs under the supervision of the lecturer, who guides students in using traditional technology tools for learning tasks that occasionally pertain to students' or real-world concerns outside the immediate instructional context. In this context, students are given opportunities to apply digital tools to content-specific tasks that are relevant to their personal experiences or that extend to challenges outside the educational setting. In goal-directed learning, students follow procedural instructions to use digital resources and online applications in standard ways, primarily to establish objectives and strategies, monitor progress, evaluate outcomes, or engage in reflection practices related to specific activities. The instructor guides students through a step-by-step process of using technological resources to define goals, plan, monitor, evaluate activities and develop reflective thinking about their learning experiences (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

2.4.3.3 Adaptation level

The third level (see Appendix H, Weeks 5 and 6) of the TIM (Shaw et al., 2018), known as the adaptation level, involves the facilitation of student exploration and independent utilisation of digital resources and online applications by the lecturer. Throughout this level, the lecturer integrates digital resources and online applications seamlessly into the lesson, and considers them to be integral components of the learning process. While the lecturer retains significant decision-making authority regarding technology usage, students are guided in independent application of digital resources and online applications. Because students gained considerable familiarity with technology tools at the previous adoption level, they can now operate without direct procedural instructions from the lecturer and start to explore diverse ways of using digital resources and online applications (Heick, 2022).

Active learning is evident, as students employ digital resources and online applications conventionally and independently. Students use technology tools autonomously, which leads to the development of conceptual comprehension and meaningful interaction with these tools. The lecturer encourages some student choice and exploration of digital tools (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018). The lecturer's direct guidance through exercises becomes redundant as the students' conceptual and procedural mastery of these tools evolves. Instead, the lecturer becomes a facilitator, promoting and supporting greater student interaction using technology tools.

In the context of collaborative learning, students autonomously employ technology tools conventionally for collaboration. While they engage in such activities, students progressively understand how to utilise technology tools for collaborative work. In this regard, the lecturer presents opportunities for students to collaborate by using technology effectively. Additionally, the lecturer takes the initiative to select and furnish technology tools that facilitate collaborative interactions and encourage students to explore these tools further (Abucayon et al., 2016). Constructive learning unfolds under the facilitation of the lecturer, who designs instructional guidelines that incorporate technology tools as essential components of building a comprehensive understanding of a concept. By granting students access to these technology tools, the lecturer guides them in exploring and selecting suitable resources, enabling them

to employ digital resources and online applications to construct meaning effectively. As students participate in this learning journey, they are empowered to explore and harness the capabilities of these tools while actively building knowledge (Heick, 2022).

At the adaptation level, authentic learning provides students with guided access to restricted information, data and source materials beyond the immediate instructional environment. This engagement prompts students to employ digital resources and online applications independently in activities beyond conventional classroom teaching and learning. The lecturer is pivotal in creating purposeful instructions that seamlessly integrate digital resources and online applications, thereby granting students access to information about community and global issues. While the lecturer directs the selection of technology tools, students utilise these tools autonomously, and some may explore additional functionalities of the tools (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018). Goal-directed learning at this level entails deliberately using tools for planning and monitoring. Students employ digital resources and online applications independently to set objectives and strategies, monitor progress, evaluate outcomes and engage in reflective practices concerning specific activities. While the lecturer may guide task breakdown, the lecturer thoughtfully selects and integrates technology tools into the teaching and learning process. Moreover, the lecturer is pivotal in facilitating students' autonomous use of digital resources and online applications for goal setting, planning, progress monitoring, outcome evaluation and reflective analysis of their learning activities (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

2.4.3.4 Infusion level

Teaching and learning at the infusion level (see Appendix H, Weeks 7, 8 and 9) feature a flexible and seamless integration of various digital resources and online applications (Shaw et al., 2018). The instructor delivers the learning information, while the students choose relevant technology tools to achieve the required results. Students must make informed judgements about when and how to use various digital materials and online technologies, while the instructional emphasis is on supporting student learning rather than emphasising the technological tools themselves. The infusion level usually occurs after the instructor and students have become acquainted with specific digital

resources and online applications. Despite this enhanced liberty, the instructor continues to advise students on when and how to use these tools successfully.

During active learning at the infusion level, the lecturer guides students by educating and contextualising their technology tool selections while being open to their suggestions. Students have a strong understanding of numerous digital tools, allowing them to choose the best ones for specific tasks and use them daily. Lessons are aimed at promoting student autonomy and independence through self-directed technology use. Furthermore, a comprehensive set of technology tools is made available to meet the diverse needs of all pupils (Heick, 2022).

Collaborative learning unfolds as students employ technology tools conventionally to collaborate with their peers and the lecturer. The instructor presents numerous opportunities for students to engage in collaborative work with digital resources and online applications. To facilitate this process, the lecturer selects and provides several tools that enable collaborative interactions while they encourage students to explore and become familiar with these tools. Students start to employ technology tools independently to produce meaning during constructive learning. Students can explore the use of technology tools while they acquire knowledge and apply their expanding conceptual understanding of these technologies. The lecturer develops instruction in which students' usage of technology tools is essential for creating comprehension of a concept. The lecturer provides students with access to technology tools and supports them in researching and selecting appropriate resources (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

In the context of authentic learning, students adeptly choose suitable technology tools to accomplish activities that hold meaningful significance beyond the instructional setting. With regular and confident usage of technology tools, students can easily select and employ the tools in the most relevant manner for each activity. The lecturer actively promotes technology tools to facilitate connections with the world outside the instructional setting, by incorporating students' personal lives and interests. In this learning context, the instructor fosters an environment in which students consistently utilise technology tools and are granted the autonomy to select the tools that align best with each individual's task requirements. In goal-directed learning, the lecturer establishes a learning context in which students consistently employ technology tools

to set goals, strategise, monitor progress, evaluate outcomes, and engage in reflection practices related to their learning activities. Students demonstrate independent use of technology to establish objectives, plan activities, track their progress, assess outcomes and reflect on their learning experiences. The lecturer actively supports students to select from a variety of technologies for working towards self-directed goals (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

2.4.3.5 Transformation level

The fifth level of the TIM (Shaw et al., 2018) is the Transformation level (see Appendix H, Week 10), at which the lecturer actively fosters the students' innovative utilisation of digital resources and online applications. Technology tools at this stage facilitate higher-order learning activities that might not have been feasible without these resources. Students possess a robust conceptual understanding of digital resources and online applications and extensive practical proficiency in their utilisation, which enables them to flexibly apply these tools to achieve specific learning outcomes. Moreover, students go beyond mere application and may even extend the use of technology tools to explore new possibilities. Throughout this transformative level, the lecturer encourages students to embrace and maximise technology tools; the lecturer assumes the roles of guide, mentor and model in utilising digital resources and online applications.

During the active learning level of the Transformation level, students employ technology tools in innovative and unconventional ways, which leads to the seamless integration of technology in the teaching and learning process. Lessons are thoughtfully designed to facilitate higher-order learning activities that would not have been attainable without the aid of technology tools. Throughout this journey, the lecturer consistently assists students to identify relevant resources and supports their decision-making processes (Abucayon et al., 2016).

Collaborative learning occurs when students frequently utilise technology tools to collaborate with peers, experts and other individuals at diverse locations, who represent various experiences, cultures and perspectives. The lecturer actively pursues partnerships beyond the immediate setting, by facilitating opportunities for students to connect with experts and peers at other locations. Furthermore, the instructor encourages students to explore and expand the utilisation of collaborative

technology tools in higher-order learning activities that would not be achievable without integrating technology tools (Heick, 2022).

Constructive learning involves broadening the use of and using digital resources and online apps creatively to promote knowledge creation. Students can use technology to create and spread knowledge in ways that would be impossible without it. Their deep understanding of technology tools enables them to extend their use creatively, resulting in meaningful knowledge construction. In turn, the lecturer encourages higher-order learning opportunities in which students consistently engage in tasks that require technology tools. The lecturer encourages students to explore unorthodox technological applications and fully utilise the potential of diverse instruments to improve knowledge-building processes (Shaw et al., 2018).

The lecturer actively promotes the creative use of digital resources and online applications to facilitate authentic learning experiences, including higher-order tasks that link students' lives and the larger world outside the instructional setting. Students welcome the opportunity to experiment with and increase their use of digital tools, which enables them to actively participate in higher-order learning activities with implications beyond the local educational context. As a result of this integration, pupils routinely engage in activities that would be impossible to accomplish without the assistance of technology (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

At the Transformation level, goal-directed learning involves substantial and advanced use of tools for planning and monitoring. The lecturer creates a robust learning environment in which students consistently engage in higher-order activities such as planning, monitoring, assessment and reflection, which may be impossible without technology. In this environment, the lecturer cultivates a culture in which students are encouraged to use technology tools in novel ways to guide and assess their learning processes. Students engage in continual metacognitive practices to pursue self-directed goals with a level of depth and sophistication that is only possible with the assistance of technology. As a result, students are empowered to push the boundaries of technology tools, resulting in a greater sense of ownership and responsibility for their learning experiences (Abucayon et al., 2016; Heick, 2022; Shaw et al., 2018).

The TIM is an excellent resource for educators who wish to fully utilise digital resources and online applications in teaching and learning. It enables lecturers to change their

instructional practice successfully by providing a complete framework with distinct levels of technology integration. This matrix facilitates the seamless inclusion of digital resources and online applications, enabling active learning, collaboration, critical thinking and creativity by students, from the basic entry level to the transformative Transformation level. The TIM is vital for educators who are navigating this dynamic landscape, as it enables them to design engaging and innovative learning experiences that prepare students for success in an ever-changing digital world.

2.5 CONCLUSION

This chapter emphasised the significance of incorporating EdTech in EGD instruction via the TPACK framework. The investigation of TK, PK and CK underscores the necessity for a balanced methodology for employing digital tools to improve teaching and learning. By comprehending and using these elements, educators can develop more captivating and efficacious learning experiences for EGD students and equip them for the requirements of a contemporary technology-oriented world. This chapter laid the groundwork for the discussion in Chapter 3, which concentrate on student teachers and their engagement with digital learning settings. Chapter 3 also explore the diverse needs of student teachers in online settings. As digital natives, these individuals possess unique traits and interests, which necessitate personalised approaches to education and technology integration. Understanding these diverse needs is essential for developing effective teaching practices and technology use and, ultimately, enhancing the learning experience.

CHAPTER 3

THE INFLUENCE OF STUDENTS' DIVERSE LEARNING STYLES AND INSTRUCTIONAL PREFERENCES ON ONLINE LEARNING AND TEACHING

3.1 INTRODUCTION

Digital technology integration has become widespread in the ever-changing environment of education (Carvalho & Santos, 2021; Sandri & Holdsworth, 2021) and has transformed the way higher education students learn and lecturers teach – this is related to the integration of digital tools in higher education (as described in this study) that relates to Education 4.0 as a response to the 4IR and the emphasis on a learner-centred approach that integrates technology into every aspect of the learning experience (see Chapter 4). In addition, it connects with the research question of the study, from a South African higher education perspective, namely, How can a technology education lecturer use a TPACK perspective to integrate EdTech for EGD first-year student teachers' online learning and teaching (see Section 1.4.2; Chapter 2)? With a focus on EdTech integration in an online learning and teaching environment, it is essential to establish the nature of the diverse student cohort in these classrooms (see Section 3.2).

In the middle of this digital transformation, the rise of Generation Z – a cohort noted for its natural affinity for technology – has provided a new perspective on the field of education (Shenkoya & Kim, 2023). Generation Z originated as a Western concept, and the globalised relevance and value of the South African higher education context have been debated (Onwuegbuchulam, 2023; Shenkoya & Kim, 2023). For example, Onwuegbuchulam (2023) states the “teaching-learning environment within the current university structures, as students (the new Generation Z learners) are more equipped with technology than typical Generation X (lecturers), which increase the complexity of education processes involving instruction, guidance, and supervision”. Additionally, Generation Z student teachers represent a specific population in teacher education programmes that possesses a specific set of abilities, attitudes and expectations about online learning settings, because of their digital birthright (Hsu et al., 2023; Van

Heerden et al., 2020). In this study, the term Generation Z student is used in its global sense, though it is not the primary focus of this research. Instead, the discussion focuses on identifying student teachers' core characteristics and the essential attributes required in an online learning environment (see Section 3.3).

In this diverse demographic context (see Section 3.2), this chapter is driven by the second subsidiary question (see Section 1.4.2.2): How do diverse students' learning styles and instruction method preferences influence online learning and teaching (see Section 3.4)? This discussion focuses on the interrelationships among four domains of human development – physical, perceptual-motor, cognitive, and social – in the context of online learning and teaching (see Sections 3.4.1–3.4.4). This discussion provides significant insights into the future of teacher education and supports the creation of effective instructional strategies that resonate with the specific characteristics of this cohort by unravelling the many elements present in online education (see Sections 3.2, 3.3; Chapter 7, with special reference to the case study university's EGD module, EGDC1614).

3.2 CHANGING DEMOGRAPHICS OF STUDENTS

The demographic composition of higher education students is undergoing significant shifts and reflects the broader changes in society and the evolving needs of student populations (Figueiredo, 2024; Meela, 2023). As more students from diverse racial, cultural and linguistic backgrounds enter higher education (Mosito et al., 2020), particularly in countries such as South Africa, the importance of inclusive practices that address these diverse perspectives becomes increasingly apparent. Today's student body is enriched by individuals from various ethnic and racial groups, diverse family structures and a variety of social and economic backgrounds. This diversity is not limited to traditional demographics but includes a wider representation of women, students with disabilities and individuals from a range of socioeconomic statuses (Black, 2010; Figueiredo, 2024; Meela, 2023).

From an international perspective, Generation Z, born between 1995 and 2012, now constitutes a substantial segment of the higher education student body and is projected to dominate enrolments until 2030 (Black, 2010; Figueiredo, 2024). This generation is recognised for its technological adaptability, comfort with digital learning

environments and ability to build diverse social networks across ethnic, racial and religious lines (LaFleur, 2023). Financially, Generation Z is said to demonstrate moderate to conservative savings and spending habits and often display a conscientious approach to financial planning (Seemiller & Grace, 2015).

In the South African context, Marnus Mostert, a financial adviser of Momentum, highlights the distinctions between Millennials (typically born between 1981 and 1996) and Generation Z (born between 1995 and 2012) in terms of financial behaviour (Axcell & Ellis, 2023). South African Millennials, because of their experience of the 2008 Global Recession, have a strong inclination towards financial security and emphasise saving and investment (Pandya, 2023; Axcell & Ellis, 2023). They often use budgeting apps, retirement annuities and tax-free savings accounts and are driven by the financial instability they experienced during young adulthood. Axcell and Ellis (2023) state that Millennials also tend to focus on long-term financial goals such as homeownership and retirement; they frequently diversify income streams in South Africa's gig economy, which encourages an entrepreneurial mindset and a cautious approach to debt. In turn, Generation Z in South Africa grew up in a digital-first world, with easy access to online banking, investment platforms and even cryptocurrency. As noted by Mostert, this generation values financial flexibility; they lean towards immediate goals, such as travel, technology and education, rather than long-term investments. Gen Z, as they are called, often relies on buy-now-pay-later services and digital content recommended by influencers to shape their financial strategies, which aligns with their preference for convenience and short-term rewards (Pandya, 2023). While Gen Z's embrace of innovative financial technologies is a notable strength, Mostert emphasises the importance of balancing this approach with a focus on long-term financial planning, avoiding impulsive spending and building lasting financial security (Pandya, 2023).

Given these dynamics, higher education institutions must consider Gen Z's unique learning preferences, social behaviours and financial attitudes. A study by Mohd Ishak et al. (Pandya, 2023) underscores that digital environments play a critical role in Gen Z's education success, and South African institutions, in particular, need to adapt curricula and financial literacy programmes that resonate with this generation's digital fluency and short-term financial goals (Axcell & Ellis, 2023; Pandya, 2023). In doing so, educators and policymakers can support multifaceted needs and enable a

generation of students who are financially aware, technologically adept and socially inclusive.

Furthermore, there has been a rise in part-time enrolment in South Africa, as students increasingly balance studies with employment. There is a notable trend towards off-campus living (i.e., commuter students), while students juggle various commitments outside their academic responsibilities (Black, 2010; Sikhwari et al., 2020).

In tandem with Gen Z, higher education is also experiencing a demographic shift, with more students opting for combined college and university pathways, greater representation of immigrant populations and the prevalence of students from non-traditional family backgrounds, such as single-parent, same-sex and blended families. These demographic changes (Meela, 2023; Menjívar et al., 2020) call for adaptive approaches to education that cater for a broader spectrum of student needs and foster inclusive and engaging learning environments that mirror the diversity of contemporary society.

3.3 CHARACTERISING STUDENT TEACHERS AND KEY ATTRIBUTES IN THE ONLINE LEARNING LANDSCAPE

In the rapidly changing educational landscape, the expansion of online learning platforms (Singh & Kumar-Roy, 2022) has been matched by the emergence of a new batch of student teachers who negotiate the world of online education (Cickovska, 2020). It has become clear that their technological competency, natural comfort with virtual collaboration and particular learning preferences characterise their education path (Cickovska, 2020; Masalimova, 2024).

3.3.1 Key characteristics of student demographics today

The student population today, encompassing Gen Z and beyond, exhibits a distinct blend of digital proficiency, social inclusivity and adaptability (Meela, 2023; Singh & Kumar-Roy, 2022). As digital natives, many current students grew up immersed in a technology-rich environment, which means they have a high level of digital literacy and a preference for multimedia and interactive and personalised learning (Singh & Kumar-Roy, 2022). They are adept at using technology for both learning and

communication, which makes them comfortable in online and hybrid education settings (Meela, 2023; LaFleur, 2023).

This generation values diversity and inclusivity and is shaped by multicultural societies and inclusive educational systems. By being raised in diverse family structures, including single-parent, same-sex and blended families, they exhibit open-mindedness to different lifestyles, cultures and perspectives (Dolot, 2018). The social values of this demographic often include a focus on social justice, thereby further highlighting the importance of integrating diversity and relevance in educational experiences.

Additionally, today's students display practical attitudes towards money (Kekana, 2023), possibly as a result of experiencing recent economic challenges, which has cultivated a cautious and savings-oriented mindset. While liberal in social issues, their approach to money is moderate to conservative and reflects a pragmatic outlook on financial management (Kekana, 2023; Salas-Velasco, 2024; Seemiller & Grace, 2015).

In terms of learning preferences, students in this demographic value both independence and collaboration. They tend to be self-reliant but are also accustomed to teamwork – a balance fostered by collaborative learning models (Glerum et al., 2020; Ohei et al., 2023). They prefer immediate feedback and interactivity, given their familiarity with fast-paced digital communication (Mofield & Peters, 2018). For many, digital engagement takes precedence over in-person interaction, which underscores the need for learning environments that offer both digital and interactive components (Glerum et al., 2020; Stamford, 2008).

Briefly, the characteristics of students today highlight a need for adaptable, inclusive and technologically enriched education strategies. Understanding these preferences and social values helps educators craft responsive curricula that resonate with a generation that values relevance, inclusivity and technological integration in their academic experiences (Masalimova, 2024).

3.3.2 Importance of understanding learner characteristics in online education

Today's students bring unique digital backgrounds, values and expectations to the online learning environment; these include a desire for immediacy in interactions,

commitment to inclusivity, a preference for interactive and multimedia learning and a strong comfort with technology (Manurung & Panggabean, 2020). Educators need to consider these characteristics and to create engaging, flexible and supportive online spaces with the aim of enhancing students' education outcomes (Manurung & Panggabean, 2020), while transforming and empowering educators professionally (Ohei et al., 2023).

3.3.3 Key attributes in online learning environments

Modern students' proficiency with digital tools enables them to navigate online platforms seamlessly, though they may find traditional, non-interactive formats less engaging (Bhandari et al., 2021). Key attributes that shape students' online learning experiences include the following:

- **Technological proficiency and digital comfort:** Students today are accustomed to digital platforms that favour self-directed, multimedia-enriched courses that include interactive content, such as videos, quizzes and forums that enhance their engagement and comprehension (Bhandari et al., 2021; Dube, 2020).
- **Preference for interactive and immediate learning:** Many learners respond positively to real-time engagement, including live feedback, online discussions and collaborative projects and thrive in environments that offer immediate, interactive experiences (Bhandari et al., 2021; Dube, 2020; Van Zyl & Fourie-Malherbe, 2021).
- **Emphasis on diversity and social awareness:** Inclusive values are increasingly important and online courses that offer diverse perspectives and safe spaces for discussion resonate well with students who seek content aligned with broader social justice themes, thereby prompting institutions to provide culturally responsive and inclusive materials (Bhandari et al., 2021; Dube, 2020).

3.4 INFLUENCE OF LEARNING STYLES AND INSTRUCTION PREFERENCES IN ONLINE LEARNING AND TEACHING

As discussed in Sections 1.1–1.1.2 and 2.4.2, technological advancements and digitalisation have transformed education profoundly over the past decade. These

changes have not only reshaped the TPK domain but have also fundamentally influenced teaching practice as a whole. According to Voithofer and Nelson (2020), in the TPACK framework, the integration of technology in education requires an intricate balance of content, pedagogy and technology, which underscores the need for educators to adapt to dynamic digital landscapes (for a comprehensive discussion, see Chapter 2). Likewise, research by Beetham and Sharpe (2019) emphasises that digitalisation has extended beyond mere tool adoption, which compels educators to rethink pedagogical approaches to facilitate deeper student engagement and more adaptive learning experiences. This shift calls for educators to continually refine their practice by ensuring that digital competence and pedagogical strategies evolve in tandem with technological advancements to meet learners' needs effectively.

Contemporary learners favour multimodal, self-paced learning that accommodates various approaches and allows them to study at their own speed, both independently and collaboratively (Hernandez-de-Menendez et al., 2020; Mahlaba, 2020). These students are skilled at quick information retrieval and multitasking across devices and they often consume content through mobile platforms. This constant digital presence also shapes their preference for dynamic, interactive content over traditional formats (Dolot, 2018; Mahlaba, 2020). In contemporary education, students have made significant contributions to shaping the educational landscape by imprinting their distinctive learning styles (Iftode, 2019). Educating the students of today requires a shift away from traditional teaching and learning approaches and encouraging educators to experiment with various techniques to effectively engage students' creativity, interests and knowledge (Pandya, 2023).

Compared to previous generations, today's students prioritise digital media over traditional TV offerings and appreciate online resources that offer flexible, engaging and participatory experiences (Nwosu et al., 2023; Van Zyl & Fourie-Malherbe, 2021). Yet, due to their high digital use, some students could experience challenges with formal writing skills, which emphasises the importance of integrating digital literacy and academic writing reinforcement in online courses (Mahlaba, 2020; Nwosu et al., 2023). Thus, today's students exhibit a notable inclination towards self-directed learning, such as acquiring skills in diverse areas, such as musical proficiency, culinary expertise or specific software. They often prefer learning independently, collaboratively and at their own pace. This proclivity for autodidacticism is particularly

evident in the popularity of online tutorials, which underscore students' ambition, self-reliance and commitment to individual growth and development (Iftode, 2019). Despite an inclination for active learning and hands-on experiences, there remains a concurrent need for students to acquire practical knowledge that is applicable to future career pursuits and endeavours (Salas-Pilco et al., 2022).

Studies confirm that students generally prefer a multimodal approach to teaching and learning and to utilise diverse sensory modalities while accommodating various learning styles (Baykan & Nacar, 2007). Puttasem (2022) found that students do not limit themselves to a single, exclusive learning style; instead, they tend to blend styles to acquire knowledge quickly and effectively. This flexibility highlights the importance of equipping students with skills to employ and adapt diverse learning strategies and styles, which serve as cornerstones for lifelong learning education (Puttasem, 2022). Mastery of multiple learning strategies enhances the efficiency of information acquisition across various contexts. In this transforming higher education landscape, it is crucial to consider four domains – physical, perceptual-motor, cognitive and social – that refer to different aspects of human development and learning processes, particularly in the context of education (Puttasem, 2022). These four main domains are deeply interconnected with online learning and teaching and influence both how students engage with content and the strategies educators use to create effective learning environments. The interrelationships between these four domains of human development in the context of online learning and teaching are explored in Sections 3.4.1–3.4.4. This structure provides a focused discussion for each domain and connects the influence of learning styles and instructional method preferences within these specific areas.

3.4.1 Physical domain and online learning and teaching

The physical domain of learning involves the bodily actions and sensory experiences through which students engage with educational content that supports the development of motor skills, hand–eye coordination and overall interaction with their environment (Han et al., 2022). This domain refers to the way students connect physically with learning materials, whether through digital tools such as tablets and virtual reality (VR) devices, or through traditional activities such as lab experiments, art and physical education. Piaget (1952), as reported by Han et al. (2022), originally

argued that the sensorimotor stage of childhood development forms the foundation for cognitive growth, as physical interactions with the environment are central to the construction of knowledge. Gibson (1988, cited by Han et al., 2022) emphasises the importance of exploratory behaviour and perceptual learning by asserting that physical engagement is essential for understanding and responding to learning affordances in one's environment.

In higher education contexts, emerging technologies that promote embodied learning, such as VR, have demonstrated significant potential for enhancing student engagement by providing immersive, hands-on experiences. Xiaoning (2024) explains how VR enhances students' learning by making abstract concepts more tangible through physical involvement. This interaction enables students to connect more deeply with the material, to increase comprehension and retention. Additionally, Parr et al. (2021) explored how motor learning principles, such as the development of hand–eye coordination and motor control, are integral to activities such as conducting science experiments or creating art, where students learn through the direct, physical manipulation of tools and materials. This body of research underscores that the physical domain supports not only cognitive and perceptual development, but also enriches the learning process by encouraging active, hands-on engagement with educational content.

With the shift towards online learning, the physical domain continues to be relevant, as students interact with digital tools and devices. For instance, students engaging in virtual field trips, simulations or interactive learning activities while using tablets, laptops or VR headsets are physically engaging with their learning environment through technology. Research by Pangrazio et al. (2020) emphasises the importance of developing digital literacy and proficiency in using various devices, as this fosters coordination between students' physical actions and the tools they utilise. As online learning environments often rely on technological interfaces, it is crucial for students to be able to interact effectively with these tools to support their learning.

Instructors, too, can design virtual hands-on experiences such as digital labs, gaming simulations or digital art creation to encourage physical interaction with the content. Even though the physical environment may differ from traditional classrooms, the need for students to engage physically with the learning materials (e.g., using a mouse,

touchpad or VR controller) remains essential for effective learning. This continuous interaction helps bridge the gap between the digital and physical realms and maintaining the importance of the physical domain in the modern education landscape.

3.4.2 Perceptual-motor domain and online learning and teaching

The perceptual-motor domain encompasses the coordination of sensory inputs such as sight, sound and touch with motor actions. This integration is essential for fine motor control tasks, including using digital devices or participating in virtual and augmented reality experiences, which are increasingly prevalent in modern education settings. Such tasks engage students in activities that demand precise sensory-motor alignment, such as playing a musical instrument or using simulation tools to navigate complex environments. Seitz (2023) emphasises that perceptual learning is a dynamic process through which individuals become attuned to environmental cues through action, which highlights how sensory input and motor responses work in tandem to facilitate learning.

A recent perspective on perceptual learning and sensory-motor integration, building on Gibson's (1979) foundational work (in Seitz, 2023), who explored how digital learning environments shape students' sensory-motor responses through interactive cues. They suggest that perceptual learning is a dynamic process, in which individuals not only receive environmental cues but actively engage with them through technology, thereby fostering deeper sensory attunement and motor coordination. This process highlights the tandem function of sensory inputs and motor responses in education settings, where interactive digital tools such as VR and AR facilitate an embodied learning experience. The study underscores the value of perceptual-motor learning for enhancing engagement and retention, especially in digital contexts that require real-time responses and interaction with virtual elements. Other studies emphasise that VR and augmented reality (AR) applications in education enhance perceptual-motor learning by providing interactive and immersive environments that help students develop spatial awareness and motor precision (Garner & Egbert, 2022).

In the context of online learning platforms, the perceptual-motor domain is particularly relevant because of the multimedia content and interactive activities that are used. For example, videos, digital games and VR simulations require students to coordinate sensory inputs (e.g., watching tutorials, manipulating virtual objects) with motor

responses (e.g., typing, clicking, gesturing). Garner and Egbert (2022) underscore that this sensory-motor integration supports engagement and learning efficacy, particularly for tasks involving digital tools and simulations, for which fine motor control is critical. Additionally, AlGerafi et al. (2023) found that AR applications in education improve perceptual-motor skills by offering hands-on experiences that reinforce students' cognitive and physical interaction with learning materials, which makes the perceptual-motor domain an essential aspect of digital literacy.

3.4.3 Cognitive domain and online learning and teaching

The cognitive domain encompasses essential mental processes such as thinking, memory, problem-solving and decision-making. It involves the methods through which students process, organise and apply information in various contexts. Cognitive development is integral to acquiring knowledge, enhancing critical thinking skills and effectively applying this knowledge in real-world scenarios. In online learning and teaching environments, the focus is on how students interact with and utilise information through digital tools, interactive platforms and self-directed study methods (Khan et al., 2021; Kharroubi, 2024; Robertson, 2011).

In today's global education landscape, particularly in the context of South Africa, the cognitive domain holds significant importance for online learning. The shift towards digital education has been accelerated by technological advancements and the necessity for flexible learning solutions, as highlighted during the COVID-19 pandemic (Mahlabane, 2020). Online learning environments offer a platform for students to engage in independent study, foster problem-solving abilities and enhance critical thinking. Features commonly found in LMSs, such as discussion forums, quizzes and multimedia resources, effectively promote cognitive engagement and encourage deeper understanding (Pradana, 2023).

Furthermore, the incorporation of multimedia elements, such as videos, infographics and interactive simulations, addresses diverse learning preferences and bolsters cognitive engagement by making content more appealing and easier to navigate (Shofawati et al., 2023). The use of adaptive learning technologies in online education also enables personalised learning pathways, which enable students to progress at their own pace and gain a more robust understanding of complex concepts (Shofawati et al., 2023).

Importantly, online learning also nurtures self-directed learning, which is a critical cognitive skill that equips students to take ownership of their education. They must manage their own learning processes, effectively organise their time and seek out various resources, thereby promoting cognitive autonomy. Instructors can facilitate cognitive development by designing activities that challenge students to apply higher-order thinking skills, such as critical analysis, synthesis of information and problem-solving (Zheng et al., 2023). By creating environments conducive to cognitive growth, educators can empower learners to thrive in an increasingly digital world.

3.4.4 Social domain and online learning and teaching

The social domain emphasises the development of interpersonal skills, communication and social interactions that are vital for student success. It examines how learners connect with their peers, teachers and others by nurturing the ability to collaborate and foster meaningful relationships. Despite the increasing use of digital tools in education, face-to-face interactions still play a crucial role in developing strong communication skills and the relationship-building abilities that are essential for success in both academic and professional contexts (Borremans, 2024).

While the social domain remains pertinent in online learning, much of the interaction occurs through digital platforms. Online education provides various tools for collaboration and communication that are essential for social learning. For instance, platforms such as discussion forums, video conferencing tools (e.g., Zoom and Microsoft Teams) and collaborative projects enable students to engage with peers and instructors, share ideas and solve problems collectively (Borremans, 2024).

Though online learners may lack the face-to-face socialisation characteristic of traditional classroom settings, educators can create rich social experiences through virtual collaboration, peer feedback and real-time interactions. Furthermore, social media tools and online study groups enable students to connect and share resources, thereby enhancing their overall learning experience (Almahdi et al., 2022).

However, the challenge remains to cultivate a sense of community and connection in virtual environments. Instructors must foster an inclusive and engaging atmosphere in which students feel comfortable about expressing themselves and participating actively in collaborative learning (Van Zyl & Fourie-Malherbe, 2021). Effective online

tools can facilitate peer-to-peer interactions and develop transferable social skills that are relevant to real-world situations (Almahdi et al. 2022).

Moreover, the importance of effective communication cannot be overstated. Digital platforms enable students to participate in discussions, collaborate on projects and refine their communication and technical skills (Hernandez-de-Menendez et al., 2020). Despite students' frequent use of various digital communication platforms, many still value face-to-face interactions for social purposes (Iftode, 2019). Their familiarity with new technologies and digital channels grants them easy access to information, which significantly influences pedagogical approaches (Iftode, 2019). Consequently, educators must tailor their instructional methods to maintain student engagement and emphasise visual and interactive learning while integrating technology smoothly.

In conclusion, the interplay between the four domains – physical, perceptual, cognitive, and social development – shape online learning experiences. Educators can design courses and activities that actively engage students across all these domains, thereby creating holistic and effective learning encounters, as expanded on in Section 3.5.

3.5 PRACTICAL TEACHING METHODS FOR STUDENT TEACHERS TO ENHANCE ONLINE LEARNING EXPERIENCES

Taking into account the four domains of human development in online learning and teaching (see Section 3.4) could assist educators with more practical applications in an online learning environment. By incorporating physical interaction with digital devices, cognitive challenges that prompt critical thinking, perceptual activities and social interactions that enhance communication skills, the integration of these domains ensure that students' diverse needs are met in meaningful ways. Additionally, Hernandez-de-Menendez et al. (2020) stress the importance of technology-enhanced learning environments that promote active, constructive, intentional, authentic and cooperative learning experiences. Thus, learning technologies support meaningful education when students control their interactions with these tools, thereby enabling deeper interpretations of subjects and fostering intellectual partnerships. Table 3.1 outlines suggested teaching and learning strategies for optimising these online learning and teaching experiences.

Table 3.1: Generation Z characteristics versus teaching-learning design methodologies and approaches

Gen Z characteristic	Teaching-learning design methodologies and approaches
High consumers of technology and cravers of the digital world	Instruct students on assessing digital source credibility and ethics, utilising online tutorials for information literacy and discussing responsible social media use. Explore innovative learning methods, including blended courses, co-curricular formats such as MOOCs, interactive gaming, virtual learning environments and e-audience response systems. Promote the adoption of interactive e-textbooks and encourage students to employ their personal technology during classroom activities.
Pragmatic	Embrace experiential learning by integrating internships and service-learning opportunities. Infuse real-life experiences in course materials and establish clear connections between theoretical concepts and practical applications through storytelling and linking classroom learning to real-life situations. Maintain transparency in teaching approaches by providing explanations for instructional decisions to enhance students' understanding of the rationale behind the teaching methods employed.
Underdeveloped social and relationship skills	Enhance accessibility of support by offering convenient office hours, both in-person and electronically. Extend engagement opportunities by arriving early or remaining after class to foster student discussions. Foster interpersonal and group processing skills through practical demonstrations and video presentations. Incorporate hands-on learning experiences, such as laboratory simulations. Optimise group and cooperative assignments by assigning clear roles and providing guidelines to streamline project editing and refinement.
Individualistic	Encourage student liberty by providing online self-study modules that allow students to work at their own speed. Encourage curriculum and coursework flexibility by offering elective courses, varying course sequencing and permitting students to select assignments from a menu of choices. This method allows students to personalise their learning experience to their specific requirements and interests, thereby improving their educational journey.

Gen Z characteristic	Teaching-learning design methodologies and approaches
Short attention span, desiring convenience and immediacy	Establish realistic expectations for availability in students. Recognise the requirement for short, targeted bursts of teaching to retain interest. To accommodate students with short attention spans, regularly rotate between teaching and learning methodologies by combining various modalities, such as lectures, debates, films and demonstrations. Prioritise in-depth subject investigation over superficial coverage and carefully filter readings to incorporate only vital information. To create a more engaging and successful learning environment, use active teaching and learning approaches such as idea mapping, flipped classrooms, case studies and problem-based learning.
Open-minded, diverse and comfortable with diversity	Promote inclusiveness and tolerance within the classroom by facilitating discussions that emphasise these values. Encourage diverse perspectives and heterogeneity in group work to foster comprehensive viewpoints among students. Utilise narratives and storytelling as a means of teaching that resonates with students from diverse backgrounds. Cultivate a creative spirit among students and nurture innovation, creativity and personal growth. Employ a variety of teaching methods and assessment techniques to ensure a well-rounded and effective learning experience.

Note. MOOCs = Massive open online courses

Source: Hernandez-de-Menendez et al. (2020)

The recommendations in Table 3.1 revolve around adapting education strategies to effectively engage diverse student populations in a technology-driven learning environment. It emphasises several key approaches that are tailored to distinct learner characteristics and challenges, which include the following:

- **Technological proficiency:** Encourage critical assessment of digital information and responsible online behaviour while exploring innovative educational methods such as blended courses and e-learning tools to enhance student engagement.
- **Experiential learning:** Integrate real-world experiences, such as internships and service learning, to connect theoretical knowledge with practical application, thereby fostering pragmatic learning.
- **Social skills development:** Provide supportive resources and structured groupwork to help students develop interpersonal skills and collaborate effectively.

- **Personalised learning:** Offer self-paced learning options and flexible curricula to cater for individualistic learners who thrive on autonomy in their education.
- **Attention management:** Employ brief instructional sessions with varied teaching methods to maintain student focus and promote deeper understanding over superficial content coverage.
- **Diversity and inclusion:** Foster an inclusive educational environment through diverse discussions, storytelling and varied assessment methods that resonate with students from different backgrounds.
- **Emerging technologies:** Acknowledge the evolving role of advanced technologies such as VR, AI and intelligent support systems in enhancing education, possibly transforming cognitive and social interactions and impacting core learning domains.

Overall, the Table 3.1 highlights the necessity for educators to be adaptable and responsive to the needs of a diverse student body, particularly in light of the technological advancements that are reshaping the education landscape. Thus, in the context of EGD online learning and teaching, interactive tools that are crucial will be discussed in Section 3.5.1.

3.5.1 Interactive tools and real-time feedback

Incorporating interactive tools, such as quizzes and polls, along with gamified elements can significantly increase student engagement. Real-time feedback on assignments and participation has been shown to enhance motivation and support continuous learning (Johnston et al., 2022; Seemiller & Grace, 2015). These features help create a more dynamic and responsive learning environment.

In EGD, using interactive tools such as quizzes and polls can actively engage students by enabling them to test their understanding of key concepts, such as orthographic projections, CAD skills and section views, in real time (Cunningham et al., 2019). Real-time feedback on assignments, such as immediate quiz scores or instant comments on digital drawings, provides students with a clear understanding of their progress, encourages continuous learning and helps them quickly identify areas for improvement. This approach fosters a dynamic and responsive EGD classroom

environment and enhances both student engagement and learning outcomes (Cunningham et al., 2019).

3.5.2 Blending synchronous and asynchronous learning

A combination of live (synchronous) sessions and on-demand (asynchronous) content provides students with the flexibility to learn at their own pace while still engaging with peers and instructors in real time. Synchronous activities, such as virtual office hours and group discussions, address the need for immediacy and connection, while asynchronous modules support self-directed learning (Brett, 2017; Hernandez-de-Menendez et al., 2020). In EGD, blending live (synchronous) sessions with on-demand (asynchronous) content offers a balanced and flexible learning experience. Synchronous sessions, including real-time demonstrations of CAD techniques and virtual office hours, enable students to engage directly with the lecturer and peers, ask questions and receive immediate feedback, thereby fostering a sense of connection and engagement (Accettone, 2021; Barche et al., 2022). Asynchronous content, such as pre-recorded video tutorials on technical drawing skills or self-paced modules on engineering principles, allows students to revisit complex topics and learn at their own pace (Accettone, 2021; Barche et al., 2022).

3.5.3 Culturally responsive content and social learning activities

Using culturally relevant materials and designing social learning activities that reflect diverse perspectives can enhance inclusivity and increase engagement. Assignments that emphasise social responsibility or incorporate diverse viewpoints contribute to a meaningful learning experience and align with students' increasing focus on social issues (Pandya, 2023). In EGD, integrating culturally relevant content and designing tasks that reflect varied perspectives can foster a more inclusive and engaging learning environment. For example, incorporating design case studies from different cultural contexts or highlighting engineering solutions inspired by local traditions can help students connect more deeply with material (Boudreau & Anis, 2022). Group projects encouraging students to collaborate and exchange diverse viewpoints support social learning and promote inclusivity (Roscoe & Jennings, 2023). Additionally, including assignments that address real-world challenges, such as sustainable design or accessibility, can increase awareness of social responsibility,

align with students' growing interest in societal impact and create a more meaningful learning experience (Boudreau & Anis, 2022).

This combination of interactive tools, blended learning formats and culturally relevant content creates an inclusive, flexible online environment that supports diverse learning needs.

3.6 CONCLUSION

This literature review chapter synthesised research on integrating EdTech in the evolving landscape of online learning and teaching in higher education. As students' learning needs become increasingly diverse, educators are encouraged to adapt instruction methods to accommodate a range of learning styles, preferences and pedagogical approaches to enhance the quality and effectiveness of digital learning environments. Digital skills and adaptability to technology remain essential, which emphasise the importance of creating dynamic and accessible online spaces that support both student engagement and meaningful learning.

The review highlighted how understanding and embracing diverse learner characteristics (including those of Generation Z) can guide the design of transformative educational experiences that leverage digital tools effectively. As educators continue to navigate the convergence of technology and pedagogy, this chapter provided insight into ways to optimise instructional strategies to meet the varied needs of the students of today.

Looking ahead, Chapter 4 explores Education 4.0 through the framework of TPACK by focusing on trends in student-centred learning, digital assessment and feedback practices to continue the examination of how educators can prepare for the challenges and opportunities of the digital age.

CHAPTER 4

EMBRACING EDUCATION 4.0: KEY TRENDS FOR INTEGRATING IN ONLINE LEARNING AND TEACHING ENVIRONMENTS

4.1 INTRODUCTION

The third subsidiary question drives this chapter, namely What are the critical trends in Education 4.0 for applying EdTech in EGD online learning and teaching? Therefore, this chapter will introduce Education 4.0 as a transformative era in education that redefines online learning and teaching dynamics through EdTech integration (Section 2.2). With a focus on TPACK (discussed in Chapter 2) in digital contexts, this chapter will analyse key trends in Education 4.0 (Section 4.2), the key characteristics (Section 4.2.1) and the advantages and disadvantages (Section 4.2.2) of Education 4.0. and to online learning and teaching environments. Then, I will address digital literacy skills that are required for both educators and students in Education 4.0 (Section 4.2.3), which will be followed by a discussion of the future of digital applications and resources in teaching that emphasises trends, innovations and implications for higher education (Section 4.2.4). I will also discuss how the current state of EdTech can be incorporated into teaching practices to address challenges/barriers versus opportunities and have a positive influence on learning outcomes (Section 4.5.2).

Considering the transforming higher education landscape, the integration of EdTech in EGD navigates a transition to student-centred learning (Section 4.3) in a digital environment (Section 4.3), thereby highlighting the pedagogical change that Education 4.0 represents. I will examine closely how trends in Education 4.0 facilitate tailored and flexible learning experiences that meet the various demands of students (as explained in Chapter 3).

In conclusion, the chapter will address how the integration of EdTech in EGD can enhance an educator's pedagogy (Section 4.4), as well as how the integration of EdTech affects online learning and teaching. This investigation will explore innovative assessment approaches in EGD education, such as peer evaluations, online tests and automated grading. These methods align with Education 4.0 principles and enhance

the learning experience by supporting a modern, effective evaluation system that fosters comprehensive skills development and engagement.

4.2 EDUCATION 4.0 AS A TRANSFORMATIVE ERA IN EDUCATION

Education is undergoing a notable transformation in the realm of Education 4.0, which is driven by the integration of technology and the application of EdTech solutions (refer to Chapter 3 for a discussion). This transformative landscape will be introduced by elucidating the key aspects of Education 4.0 (Section 4.2.1) by thoroughly examining its fundamental ideas and essential features. Then, the focus will shift to analysing digital online learning environments, in order to understand their intrinsic qualities and advantages that contribute to the modern education experience (Section 4.2.2). In this context, I explore the crucial digital literacy abilities that educators and students need (Section 4.2.3) to effectively navigate the intricacies of Education 4.0. Moreover, I focus on the future and consider the path of EdTech in education (Section 4.2.4). A discussion of current trends, innovations and the wider consequences for education offer valuable insights into the always-changing landscape (Section 4.2.5), that leads to a more detailed comprehension of the dynamic factors involved in Education 4.0.

4.2.1 The concept of Education 4.0 and related key characteristics

The 4IR has significantly impacted various facets of modern life and its influence extends to the education system (Mansor et al., 2020). Although the concept of Education 4.0 is widely applied by educationists, a formal definition seems to be lacking. Instead, it is primarily defined by its core characteristics. In general, it is described as a learning approach that is connected with the 4IR and which focuses on transforming the future of education through advanced technology and automation (Suhaimi et al., 2023). Smart technology, AI and robotics are part of this industrial revolution (Elsakova et al., 2019).

The arrival of Education 4.0 marked the implementation of an entirely novel teaching and learning environment. This paradigm shift encompasses dynamic learning, fostering high levels of creativity, conducive classroom settings and the integration of green technology (World Economic Forum, 2023). Education 4.0 also represents a forward-thinking approach to learning that corresponds harmoniously with the

upcoming 4IR. This paradigm shift involves reevaluating key notions such as meaning, technology, teaching, schools and educators (Himmetoglu et al., 2020).

The core aspects of Education 4.0 include aiming to create lifelong learning experiences by integrating technology in the learning process to create personalised learning experiences, by focusing on developing critical skills such as problem-solving, collaboration and adaptability. In addition, Das et al. (2020) identify the following nine key characteristics of Education 4.0: diverse times and places, personalised learning and individuals' learning styles, project-based learning, field experiences, exploratory education, data interpretation, shifts in the assessment of learning, student ownership and significance of mentoring.

In the first place, diverse times and places are pivotal in this education paradigm. Students must be allowed to learn at varying times and locations, which necessitates the implementation of concepts such as e-learning, HyFlex (Bonderud, 2023; Wallner & Wagner, 2016), flipped classrooms, opportunities for independent theory learning or hands-on application during in-person sessions, and so on. This approach allows students to choose between on-site, synchronous online or asynchronous online participation (see Section 4.2.4).

Students also require the ability to learn at their own pace, which emphasises the significance of personalised learning as part of the integration of technology (Eden et al., 2024) in the framework of Education 4.0. Hence, when EdTech is employed in education, it must be adaptive. This adaptability ensures that students with advanced capabilities can progress swiftly to tackle more challenging tasks, while those facing difficulties can take the necessary time to master specific skills before advancing (Das et al., 2020; Wallner & Wagner, 2016).

Second, closely intertwined with the principles of diverse time and place is personalised learning, which Himmetoglu et al. (2020) call individualised education. These features of personalised learning encompass learning analytics, individualised learning content and adaptive learning materials. Students' freedom of choice is paramount (Das et al., 2020; Wallner & Wagner, 2016).

In recognising the diversity of higher education student profiles today, as well as the third characteristic, individuals' learning styles and instruction mode preferences, it is imperative that students are at liberty to employ their unique combination of learning

tools and methodologies. Education unfolds as a personalised journey, with students utilising different devices, programmes and techniques, which are tailored to their individual preferences (Das et al., 2020; Wallner & Wagner, 2016).

The first three characteristics concentrate on learning styles, while the next two emphasise learning pedagogy in Education 4.0. Authenticity is paramount in this context, and it necessitates a shift towards the fourth characteristic, project-based learning, which closely mirrors real-world scenarios in which skills such as organisation, teamwork, time and project management are crucial (Hartati et al., 2022). In this framework, the significance of practical experience is heightened, which makes it imperative for students to engage in the fifth characteristic, field experiences, such as internships, industrial projects, co-ops and mentoring. This approach is intended to prepare students for the intricacies of the professional world (Das et al., 2020). Thus, Education 4.0 also places a strong emphasis on exploratory education, by incorporating application-oriented learning that centres around learning by doing, transforming ideas into practice and moving away from rote learning.

Although modern computers are capable of performing the mathematical tasks that have historically been emphasised in student education, I realise that the significance of these skills is decreasing, though they remain important for conceptualisation and application purposes in data and statistic interpretation (Das et al., 2020). However, the sixth characteristic, data interpretation and drawing logical conclusions, is expected to become a dominant trend in the future.

The seventh characteristic refers to paradigm shifts in the assessment of learning. For example, exams will change completely. This shift in assessment practices will have a profound influence on the nature of tests, with the emphasis shifting from mere memorisation to the practical application of knowledge and the display of mastery in skills as learning progresses (Das et al., 2020; Wallner & Wagner, 2016). Education 4.0 emphasises a revolutionary method by which students gain greater authority over their learning process and become experts in their educational journey. Through ownership, students have an increased ability to shape curricula and create personalised goals.

To create a thorough study programme, it is crucial to obtain students' opinions (i.e., the eighth characteristics, student ownership) on the content and long-term viability of

their courses. Doing so will promote a cooperative and all-encompassing educational atmosphere (Wallner & Wagner, 2016).

With the ninth characteristic, Das et al. (2020) highlight that educators and other experts must transition into roles that resemble that of mentors in the teaching and learning environment. Thus, the significance of mentoring is set to increase, and mentors will play a crucial role in aiding students to navigate the abundance of information at their disposal. The guidance of mentors becomes invaluable for assisting students to chart a meaningful path through the complexities of information available to them (Bonderud, 2023; Wallner & Wagner, 2016).

Sung et al. (2024) assert that challenges are becoming progressively more interdisciplinary and transdisciplinary, thus rendering a stable and well-defined range of subjects obsolete. Thus, interdisciplinarity is another important characteristic of Education 4.0; it is imperative to broaden students' views by providing a structural overview of their field of study and facilitating the integration of the constantly evolving knowledge they acquire.

In Education 4.0, students play an essential role in shaping the learning process by contributing through innovative feedback that enriches teaching (Himmetoglu et al., 2020). Educators provide a framework that helps students connect and apply knowledge meaningfully. Innovation-focused practices of individuals or teams facilitate learning and take place in a globally networked environment in which educators can be anyone and anywhere, and serving as sources of inspiration. Education 4.0 redefines learning, students, lecturing and schools to meet the demands of Industry 4.0 (Himmetoglu et al., 2020).

Himmetoglu et al. (2020), in turn, identified eight key characteristics of Education 4.0 and I will discuss those that do not correspond with the characteristics proposed by Das et al. (2020). The first characteristic involves the integration of digital technologies in education, including, emphasising VR, AR, AI, mobile technologies, blockchain applications, cloud computing technologies, flipped classrooms, social-network-based learning and smart campuses. Additionally, open access encompasses MOOCs (massive open online courses) and open educational resources. Education 4.0 emphasises lifelong learning, incorporating sustainability by cultivating learning skills and a dedication to continuous improvement (Himmetoglu et al., 2020). Mental

transformation, which encompasses the philosophical evolution of human resources, and multidisciplinary education constitute additional components of the eight characteristics outlined by Himmetoglu et al. (2020). The final characteristic pertains to seamless learning environments, which specifically address open and distance learning, thereby emphasising the idea of education being accessible at any time and at any place. Therefore, the discussion in Section 4.2.2 will focus on the advantages and disadvantages of online learning environments.

4.2.2 Advantages and disadvantages of online learning and teaching environments

Considering the unique characteristics of Education 4.0 (Section 4.2.1), the advantages of digital online learning settings offer a significant understanding of the ever-changing field of contemporary education. The learning process has changed, from being teacher-centred to involving adaptive learning, while students have become active participants to achieve their personal goals (Mejeh, 2024). Today, personal goal success relies upon students' course interest, options of instructional methods, capability and academic support strategies. This shift in the learning process needs to run parallel with the teaching method (Mejeh, 2024). Teaching methods centred on personalised learning incorporate e-learning and integrate various AI applications. This approach promotes active student engagement and ensures they participate in an optimal learning process (Mansor et al., 2020).

Mansor et al. (2020) state that students construct a system of meaning and learn through physical and mental activities specifically created by real-time and real-world active learning. In EdTech learning environments, the educator fulfils the role of mentor. Although self-motivation is important to make sure learning goals are achieved, the lecturer needs to guide and monitor the students through the teaching and learning process (Mansor et al., 2020) because, in an EdTech learning environment, learning can occur at any time and anywhere. Students are empowered to discover their learning styles and choose freely accessible resources for convenient access (Mansor et al., 2020). By utilising freely accessible resources, students increasingly engage with asynchronous technology, which fosters reflection and consequently promotes higher-order thinking (Koehler et al., 2020). Moreover, online courses foster greater collaboration among students, resulting in increased

engagement patterns compared to face-to-face situations in which students merely sit in class.

Online learning also allows individuals to acquire knowledge on various subjects at any time and at any location. This benefit is particularly valuable, because continuous learning is a crucial factor for achieving success and personal and professional growth (Thompson, 2023). Furthermore, online learning allows educators to explore a plethora of more effective approaches to disseminating instructional content, which are not available in the conventional classroom environment (Al-Rawashdeh et al., 2021). Online learning incorporates diverse multimedia components, such as written content, videos, audio, collaborative sharing and interactive graphics that actively engage students in teaching and learning. Not only is online education more efficient, because teachers have access to more effective delivery techniques, but it also provides online students with the chance to access a wider range of courses, programmes and educators, which may not be as readily available in a traditional classroom setting (Thompson, 2023), ensure continuation and stimulate motivation.

Online lessons are convenient, because students can take courses in the privacy of their own homes, hence increasing flexibility. Online learning platforms frequently integrate functionalities that foster collaboration and communication among students (Eden et al., 2024). By participating in online conversations and collaborative assignments and receiving input from both classmates and instructors, students have the opportunity to actively participate in social exchanges and improve their abilities to work effectively in teams (Thompson, 2023).

Despite the advantages of online learning, Thompson (2023) also identifies a couple of disadvantages. The absence of face-to-face interaction in online learning leads to limited social engagement, which could hamper the development of social skills and personal connections among students (Al-Rawashdeh et al., 2021; Thompson, 2023). Technical challenges can be a disadvantage; stable connectivity and access to suitable devices can be problematic, especially for students in low-income households. Both lecturers and students can experience frustration because of issues with the learning platform and compatibility problems (Al-Rawashdeh et al., 2021; Thompson, 2023).

In the domain of online education, students may often succumb to self-distraction – online learning requires a considerable degree of self-motivation and discipline. Hence, individuals who encounter difficulties with self-regulation may find it difficult to successfully manage their time and stay on top of their homework (Thompson, 2023). Distractions can originate from multiple sources, including noise, domestic tasks, or the availability of personal devices unrelated to the education process. Ensuring a learning-friendly environment might be more difficult online, and it could impact student focus and efficiency (Al-Rawashdeh et al., 2021).

Thompson (2023) and Eden et al. (2024) identify two more disadvantages, these are related to equity and accessibility. First, these authors confirm that not all students have equitable access to essential technology or a dependable internet connection. Second, they explain that students who are from disadvantaged origins or have limited proficiency in using digital technology may face challenges that hinder their complete participation in learning.

Digital online learning environments have distinctive attributes and benefits that offer students exceptional adaptability, information enriched with multimedia and opportunities for collaboration (Al-Rawashdeh et al., 2021). It provides unparalleled versatility, integration of multimedia and possibilities for collaborative involvement. These various elements collectively contribute to a dynamic and inclusive educational experience, hence improving accessibility and engagement for a diverse spectrum of students.

4.2.3 Digital literacy skills required for both educators and students in Education 4.0

Education 4.0 highlights the importance of digital literacy skills and emphasises that both instructors and students must be able to adapt to the changing world of technology-driven learning. Mansor et al. (2020) state that the skill set required of lecturers and students entails the ability to do complex problem-solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgement and decision-making, service orientation, negotiation and cognitive flexibility. In the context of Education 4.0, which requires transitioning from a teacher-centred approach to adaptive learning, it is essential to utilise these abilities in the teaching and learning environment (Rane et al., 2024).

Education 4.0 relies primarily on electronic learning and the incorporation of various AI applications, which highlight that the integration of EdTech should be embraced ethically and responsibly. Hence, it is crucial to possess a significant level of expertise in utilising technology, namely social media, LMSs and cell phones (Rane et al., 2024). Both students and lecturers must be able to generate, distribute, react to, assess, oversee and handle content on LMSs (Mansor et al., 2020). Lecturers require essential skills in content development, which encompass writing in digital formats such as emails, blogs and tweets and creating various media forms, such as videos and podcasts (Khawar, 2023). It is important that lecturers know how the most up-to-date digital technology and incorporate it with current knowledge, reliable multimedia files and relevant and accurate resources.

Koehler et al. (2020) highlight the necessity of lecturers understanding the influence of technology and emphasise the need to evaluate students' proficiency in digital literacy, especially at the start of module/programme. Students must acquire fundamental digital literacy to efficiently access and utilise information (Mammadova, 2023). In addition, students should possess the ability to recognise authors, analyse their qualifications, and evaluate the reliability of particular websites and then be able to transfer their knowledge and skills in digital literacy to any applicable experience and integrate it into their academic writing and oral presentation skills (Mammadova, 2023).

Although Generation Z is commonly characterised as being skilled with technology, Erwin and Mohammed (2022) explain that it is not universally accurate to claim that all individuals in this generation possess the essential abilities required for achieving success in further education and future professional environments. Hence, it is imperative to avoid focusing only on enhancing students' digital literacy; instead, the pragmatic implementation of those abilities must also receive attention. In order to include digital skills effectively in teaching and learning, students must possess and cultivate proficiencies in critical thinking, creativity, teamwork and problem-solving (Khawar, 2023).

Digital literacy, also known as 21st-century competency, refers to a set of skills that is closely associated with research, innovation and technology. Contemporary digital media consumers employ critical thinking, effective communication and collaborative

skills to solve problems. These talents are becoming ever more and more crucial in a rapidly changing environment.

4.2.4 The future of EdTech in teaching: Trends, innovations, and implications for higher education

In the transformed landscape of higher education that is primarily driven by EdTech, educators recognise the importance of human interaction in education settings and its role in ensuring that all the latest teaching tools can be applied effectively (Nordrum & Gracia, 2023). Thus, it is anticipated that, by 2050, nearly 9 billion individuals will be able to participate in EdTech learning, because 90% of the world's population will have access to broadband internet (Nordrum & Gracia, 2023). There will, undoubtedly, be a shift in the digital footprints that higher education institutions leave. Because more time will be spent online than in a real classroom, there will be a distinct shift from physical to digital delivery of services such as textbooks, tech support and course materials (Nordrum & Gracia, 2023).

Mammadova (2023) proposes that the global game-based learning market was worth approximately \$1.0 billion in 2021 and it is estimated that, by the end of 2023, the worth will be \$29.7 billion given a growth rate of 21.8%. This significant growth rate makes gaming the most innovative trend shaping the future of education (Mammadova, 2023). Game-based learning encourages students to learn different concepts or subjects through playing games; game playing also aids in students' understanding and comprehension of concepts and their retention of concepts or subjects (Naseri et al., 2022).

Additionally, cohort learning is developing as a key trend for future online education (Naseri et al., 2022). This method entails gathering learners in a collaborative and interactive online environment and encouraging them to advance as a cohesive cohort through a course, module or programme. Cohort learning encourages peer-to-peer involvement, knowledge exchange and collaborative problem-solving. Learners also benefit from their peers' encouragement and motivation and the creation of a dynamic learning environment, also called peer-assisted learning or peer support (Naseri et al., 2022). This practice encourages learners' active participation, accountability and deeper relationships, thereby improving their overall learning results. Online education is evolving to deliver a more engaging, interactive and successful learning experience

in the future, by using the power of technology to support cohort learning (Intrepid by VitalSource, 2023).

AI has taken the world by storm, and AI tools such as ChatGPT are opening new doors for teaching and learning regarding content creation, communication and learning. The report *20 AI in Education Statistics to Rethink how you teach 2023* (Soocial, n.d.) reports that, by 2026, over 47% of all learning management tools will be AI-driven. The same report also states that between 20% and 40% of the current workload of teachers can be automated through AI and that a teacher's preparation time can be reduced to five hours a day. Using an AI-enabled chatbot means students will no longer have to wait hours for their questions to be answered, instead, a chatbot can answer a student's question in merely 2.7 seconds (Soocial, n.d.). In the near future, more than half of LMSs will be AI-enabled, leading to an education system that is not only AI-driven but also highly advanced in its teaching methods (Intrepid by VitalSource, 2023).

Education communities are also emerging as a prominent trend for the future of higher education. These communities align closely with communities of practice, which involve groups of individuals who share a common interest or profession, who collectively enhance their knowledge through regular interaction and shared experiences (Intrepid by VitalSource, 2023). Learning, which is often a solitary endeavour, is becoming more challenging. In education, communities of practice can create supportive environments in which students can collaborate, gain insights from diverse perspectives and explore various fields. This collaborative approach is becoming increasingly valuable as learning becomes more challenging and requires broader support networks. However, the increasing prevalence of educational communities is proving to be a significant source of support. These communities offer students from various backgrounds a pathway to explore different fields (Intrepid by VitalSource, 2023).

Furthermore, MOOCs are college-level online courses that are offered free of charge (Intrepid by VitalSource, 2023). These courses have gained significant traction and align well with the futuristic education model. Several online learning platforms, such as edX, Udacity, Khan Academy and Coursera, provide MOOCs. The global popularity of MOOCs has soared, with Coursera alone witnessing a substantial increase in

student enrolment: By 2021, the number of registered students for Coursera classes reached an impressive 92 million, a significant surge from 21 million in 2016 (Intrepid by VitalSource, 2023).

According to Naseri et al. (2022), the future of education will shift from a “learn from anywhere” (providing flexibility) approach to a “learn from everywhere” (providing immersion), with hybrid learning allowing for truly immersive and experiential learning, allowing students to apply concepts learned in the classroom out in the real world. Mobile-based devices give great assistance to the last-mentioned trend (Naseri et al., 2022).

Using social media as a tool for teaching and learning is a topic that warrants consideration. In contemporary times, even individuals as young as 11 actively maintain social media profiles across multiple platforms (Naseri et al., 2022). The prevalence of young users unequivocally suggests that social media will assume a significant role in education in the future. By using social media platforms, students can exchange study materials, express their viewpoints and present their projects, among other activities. By leveraging social media, students can comment on posts their peers authored and share pertinent website links. Moreover, they can establish and cultivate peer networks, foster education-related communities and augment their online learning experiences (Naseri et al., 2022).

Kerimbayev et al. (2023) offer a comprehensive examination of emerging technologies and trends in education and highlight six noteworthy trends that have risen to the top of an extensive list of potential technologies and practices for the future. These trends include using AI for predictive and personalised learning, adopting generative AI for new educational experiences, blending different learning methods, offering flexible HyFlex options (on-site, live online, or recorded online), integrating micro-credentials for skills recognition, and focusing on building students’ sense of belonging. (Kerimbayev et al., 2023). These trends represent significant developments that can shape the future of education and have implications for educators, administrators and policymakers alike.

Kerimbayev et al. (2023) state that AI will strongly inform the design of personalised learning tools by facilitating the transition from “one size fits all” technology to scalable implementations of personalised learning experiences. Not only will lecturers gain

more time, but students will have 24/7 access to support via chatbots; LMS platforms that are fully supported by AI could become the new standard (Sung et al., 2024). According to Kerimbayev et al. (2023), generative AI is widely recognised as one of the most transformative technologies of our era and for the future. It's a remarkable ability to generate text, images and sounds that closely resemble human creations has the power to revolutionise instructional materials, assessments and other domains (Kerimbayev et al., 2023; Mejuh, 2024), though it requires responsible and ethical application.

Blurring the boundaries between learning modalities will provide students with a multidimensional and diverse learning environment that caters for individual preferences and optimises learning (Mejuh, 2024). Blurring the boundaries between learning modalities can involve incorporating interactive simulations, VR experiences, multimedia presentations, hands-on activities and collaborative groupwork into the learning process (Mejuh, 2024). By doing so, students can benefit from a more comprehensive understanding of the subject matter and enhance their retention and application of knowledge. Blurring the boundaries embraces technology, digital resources and online platforms to enable students to access educational content at any time and from anywhere (Kerimbayev et al., 2023).

Learning modality received much attention during the COVID-19 outbreak and is still a hotly debated topic. The HyFlex modality (Section 1.6.5) is a distinct teaching and learning strategy among learning modalities that should not be confused with other modalities. HyFlex is a course design that allows students to choose between attending in-person courses and engaging online, all as part of the same course (Battestilli et al., 2023). Notably, students who have enrolled for a HyFlex course can switch between modalities as needed throughout the course. The HyFlex model meets the needs of students who must manage multiple conflicting duties and maintain the essential mission of higher education, which centred on the pursuit of knowledge (Kerimbayev et al., 2023).

The fifth trend listed by the panel of the Horizon Report (Kerimbayev et al., 2023) is micro-credentialing and micro-learning, which offer attractive options for building personalised, flexible learning pathways. The practice of obtaining small, specialised certifications or badges that recognise specific abilities or knowledge in a particular

sector is called micro-credentialing. These certificates are often customised to match industry-specific competency expectations and give learners visible proof of their learning (Tee, 2023). Conversely, micro-learning offers educational content in bite-sized, easily accessible formats, typically through brief modules or lessons. The goal is to provide complete and concise learning experiences that are easily accessible and finished, which makes it a suitable strategy for learners with limited time available or those wishing to master specific skills quickly. Micro-credentialing and micro-learning play critical roles in satisfying the demands of lifelong learners and professionals who wish to upskill or reskill in the fast-paced and ever-changing environment of today (Tee, 2023).

Supporting students' sense of belonging and connection will be a significant trend in education in the future. By recognising the importance of social and emotional variables for students' general well-being and academic success, education institutions emphasise the need to establish a sense of belonging within the learning community (Walton, 2023). A key component is creating inclusive settings in which students feel valued, accepted and connected to their classmates, professors and the institution. Strategies such as mentorship programmes, peer support networks, collaborative learning opportunities and culturally relevant practices are being used to foster a sense of belonging (Walton, 2023). In the future, education will strive to improve student engagement, motivation and general pleasure by emphasising students' understanding of belonging and connectedness and, ultimately, contributing to their holistic development and lifelong success (Kerimbayev et al., 2023).

Several key trends characterise the future of technology in education. Blended and hybrid learning approaches mix face-to-face and online training to provide flexibility and personalised learning experiences (Rae, 2021). Adaptive learning and AI personalise training according to student needs, while VR and AR increase experiential learning. Data analytics and learning analytics can help to influence instructional decisions and improve student achievement. Mobile learning provides educational resources at any time and from any location (Rae, 2021). These developments indicate the growing integration of technology to enhance teaching, learning and administrative operations, which will, ultimately, produce a dynamic and inventive future for education.

4.2.5 The current state of EdTech integration in teaching: Challenges, opportunities and current trends

In today's quickly changing digital landscape, incorporating EdTech in education has become important. The education sector is changing as educators and institutions investigate new ways to improve students' learning experiences. The seamless integration of technology in the classroom presents both obstacles and opportunities, which necessitates a thorough awareness of its ramifications (Adhikari, 2021).

Most of the higher education students of today grew up with fast video games, blogs, social networks, cooperative learning and live virtual classrooms (see Sections 3.2 and 3.3). Once they reach higher education levels, students spend significant amounts of free time online, learning and exchanging new information (Adhikari, 2021). Hence, students have little tolerance for formal lectures, well-ordered guidance and conventional reasoning or assessment methods. Compared to their encounters with digital technology, they find traditional teaching methods dull (Adhikari, 2021). By viewing interactivity as a vital component of an interactive, student-centred classroom approach, students expect technology-based activities to enhance interactivity during lectures (Digital Classroom Services, 2023). These expectations affect how lecturers teach and how future teachers must be trained, particularly in cases where self-regulated learning is required.

4.2.5.1 Trends in the integration of digital applications and resources in teaching

Since the COVID-19 pandemic, distance learning has become the trend that outperforms previous trends, such as Big Data, machine learning and the Internet of Things. Online learning and teaching through digital platforms remain tangible, thereby emphasising connectivity, versatility and a student-centred approach (Xie et al., 2020). Xie et al. (2020) and Pokhrel and Chhetri (2021) make it clear that it is essential to keep up with innovative education technology trends and that doing so will empower educators to elevate the student experience and take the burden of repetitive tasks off both the educator and student shoulders. During the global closure of institutions as a preventive measure for the transmission of COVID-19, distance learning swiftly emerged as the dominant mode of education delivery. Consequently, there was a notable surge in demand for **e-learning** platforms, making this technology an instantly

popular trend in the education landscape (Pokhrel & Chhetri, 2021). Numerous institutions subsequently transitioned back to traditional physical classrooms, though the advent of e-learning introduced a newfound realm of possibilities for educators to impart knowledge to students, unencumbered by the confines of a physical learning environment (Pokhrel & Chhetri, 2021). According to Marr (2022), there is a projected annual growth rate of 15% for the market of online learning services and e-learning in the period 2020 to 2025. This growth is anticipated to culminate in a market value of \$50 billion.

Video-assisted learning is increasingly being used in conjunction with e-learning. The use of videos has expanded into several creative solutions enabled by the internet and digital gadgets, leading to tremendous growth in distance learning (Marr, 2022). When students learn through computer screens, videos are essential for improving instructional delivery and boosting comprehension of course information (Marr, 2022). Pokhrel and Chhetri (2021) explain that video-assisted learning allows students to watch lecture videos at any time, instead of at the time of a real-time class (in the case of e-learning). This medium predates the need for widespread e-learning and is a much more subtle medium that has been instrumental in distance learning (Pokhrel & Chhetri, 2021).

Blockchain technology has the potential to improve education significantly. Blockchain can improve numerous areas of the education ecosystem by exploiting its decentralised and transparent character (Pokhrel & Chhetri, 2021). The secure storage and verification of academic credentials, such as degrees and certificates, is an important application. Credentialing systems based on blockchain can provide immutable records, removing the possibility of false credentials (Pokhrel & Chhetri, 2021). Furthermore, blockchain enables the efficient and transparent maintenance of student records, while preserving data integrity and privacy (Marr, 2022). Blockchain-based smart contracts can automate money disbursements and course enrolments, thereby reducing administrative work. Furthermore, decentralised learning platforms enabled by blockchain can empower learners by giving them control over their data and facilitating peer-to-peer communication (Xie et al., 2020). Overall, blockchain technology has the potential to enhance trust, transparency and efficiency in education, to transform the way credentials are verified, records are managed and learning is facilitated (Marr, 2022; Pokhrel & Chhetri, 2021; Xie et al., 2020).

With the introduction of Big Data, cloud technology, the Internet of Things, mobile learning and VR, the potential of enriching gamified learning was lifted (Xie et al., 2020). Gamification offers a wealth of opportunities for lecturers and institutions. Adopting game thinking and mechanics in non-game environments has been shown to boost engagement levels, aid in task completion, improve individual learning and foster personal development (Xie et al., 2020).

With the widespread adoption of distance learning in the wake of pandemic-related shutdowns, educational institutions have gathered a wealth of substantial datasets (Xie et al., 2020). The shift to remote operations provided a unique opportunity for these institutions to gather student data, which give valuable insights into student responses and levels of engagement. While this data has the potential to enhance the student learning experience significantly, it could be a challenge to extract critical information from this deluge. This is precisely where the utilisation of Big Data comes into play (Marr, 2022; Pokhrel & Chhetri, 2021; Xie et al., 2020).

Effectively identifying meaningful knowledge within the collected data necessitates the application of specific methodologies. Such data can illuminate the outcomes of adopted teaching techniques and enable educators to refine their curriculum and assess students' performance (Pokhrel & Chhetri, 2021). By comparing education methods and approaches to student achievements, teachers can be empowered to identify the most effective strategies. This process equips educators to adapt and optimise their instructional practices, resulting in improved educational outcomes (Marr, 2022; Pokhrel & Chhetri, 2021; Xie et al., 2020).

Learning analytics has developed as a prominent trend in higher education by utilising data-driven insights to improve learning and guide decision-making. It entails gathering, analysing and interpreting student data to gain meaningful insights into their learning patterns, behaviours and results (Pokhrel & Chhetri, 2021). Learning analytics can help schools identify at-risk students, personalise learning experiences and optimise instruction tactics (Pokhrel & Chhetri, 2021; Marr, 2022). Learning analytics also give instructors usable data that can be applied to evaluate student progress, identify areas for improvement and intervene proactively, as needed. Furthermore, learning analytics can assist administrators in making informed decisions about curriculum design, resource allocation and student support services by facilitating

evidence-based decision-making at the institutional level (Marr, 2022; Pokhrel & Chhetri, 2021). As a trend in higher education, learning analytics holds immense potential for improving student success and advancing the overall effectiveness of teaching and learning practices (Marr, 2022).

Immersive learning with VR and AR has emerged as a fascinating trend in higher education. VR technology creates simulated worlds in which students can interact and view virtual content, giving them immersive and realistic learning experiences (Xie et al., 2020). AR, conversely, superimposes digital information on top of the natural environment and enriches it with contextual information and interactive aspects. Immersive technologies have enormous potential in higher education because they enable students to engage in hands-on experiential learning in science, medicine, engineering and the arts (Xie et al., 2020). Students can study complex subjects, practise skills in a safe setting and improve their understanding through VR and AR interactive simulations (Marr, 2022). These technologies promote active learning, critical thinking and problem-solving abilities, thereby improving the educational experience. Higher education institutions should embrace VR and AR as immersive learning technology that can provide students with unique and exciting ways to gain knowledge and skills (Xie et al., 2020).

In higher education, cloud technology has emerged as an essential and transformational trend (Marr, 2022). It refers to using remote servers, storage and applications available via the internet, that enable organisations to store, manage and process data more efficiently and securely. Cloud technology has many advantages for higher education, including scalability, cost-effectiveness and flexibility (Marr, 2022). Education institutions can use cloud-based platforms and services, including virtual classrooms, collaboration tools and data storage solutions (Marr, 2022). The cloud enables students and staff to interact and engage in learning activities from anywhere, at any time, by facilitating seamless access to educational resources and information (Marr, 2022). Furthermore, through data analytics, cloud technology enables institutions to acquire significant insight into student performance, learning patterns and administrative operations. Cloud technology continues to influence and transform higher education institutions and help them to achieve their goal of offering quality education to an increasingly digital and connected student body, through its

potential to improve accessibility, streamline operations and promote innovation (Marr, 2022).

The COVID-19 pandemic and the acknowledgement of the 4IR have significantly influenced the recent higher education trends in South Africa (Küçük-Avci, 2022). This period underscored the urgent need for innovative change to ensure the enduring relevance and currency of education (Küçük-Avci, 2022). Notably, the pandemic expedited the shift toward digitisation, by compelling students and lecturers to adapt to remote e-learning facilitated by digital platforms. Consequently, conventional face-to-face teaching approaches gave way to novel pedagogical practices in education. Moreover, an enhanced focus on higher education institutions offering distance, online and blended learning options has emerged as a prevailing characteristic in South Africa (Küçük-Avci, 2022).

It has become critical for online LMSs to be accessible and user-friendly, as this helps to make education more accessible and contributes to the goal of “education for all” (Beans, 2022). Students anticipate a consistent experience when they access their learning platform and adding downloadable tools for offline study helps alleviate cost and connectivity concerns. Accessible learning systems have become essential for online learning, resulting in increased recognition of online education (Küçük-Avci, 2022).

According to Küçük-Avci (2022), humans possess an inherently social nature and students may encounter challenges when adapting to online classroom environments. Consequently, education institutions in the higher education sector have adopted platforms such as WhatsApp, Zoom and Google to address this on integrating human contact (Beans, 2022). These platforms have revolutionised classrooms and transformed the nature of examinations (Küçük-Avci, 2022). Virtual open-book and oral exams have emerged as alternatives to traditional exams, and encourage students to comprehend concepts instead of relying solely on rote memorisation (Beans, 2022). As a result, students become more collaborative and engaged in the learning process.

According to Beans (2022) and Küçük-Avci (2022), students exhibit higher motivation levels when they are engaged in blended learning models that incorporate various components, such as online lessons, workshops, webinars, individual project reviews,

practical sessions and, when feasible, in-person lectures. Blended learning models offer the advantage of flexible delivery modes (Beans, 2022). Presently, there is a noticeably increasing trend in the number of applications submitted to the national higher education regulator in South Africa, the Council on Higher Education, and seeking accreditation for programmes offered in blended modes by public and private higher education institutions. The primary driving force behind the adoption by many higher education institutions of blended learning appears to be the desire to reach a larger student population than what is achievable through traditional face-to-face instruction alone. Higher education institutions are experimenting with different delivery modes to optimise student achievement and success (Beans, 2022).

The *Digital 2023: South Africa* report by Kemp (2023) presents several key statistics about internet and mobile usage in South Africa. At the start of 2023, there were 43.48 million internet users, representing a penetration rate of 72.3%. Furthermore, there were 25.80 million social media users in January 2023, which accounted for 42.9% of the total population. The report also lists 112.7 million active cellular mobile connections in South Africa in early 2023, which exceeds the total population by 87.4%. These figures indicate a substantial internet and mobile technology presence in the country. Notably, at the start of 2023, 16.66 million individuals in South Africa were not using the internet, indicating that 27.7% of the population were offline (Kemp, 2023).

Additionally, data from various advertising resources reveal that Facebook advertisements reached 36.8% of the total population (Kemp, 2023), while YouTube had 25.80 million users and TikTok 11.83 million users aged 18 and above in early 2023 (Kemp, 2023). The number of mobile connections in South Africa witnessed a growth of 4.0 million (+3.7%) between 2022 and 2023, according to data provided by GSMA Intelligence. These findings underscore the significant role of digital platforms and mobile technologies in the communication landscape of South Africa (Kemp, 2023).

Digital apps and resources in the classroom continue to expand and alter the education landscape. Current trends show a growing reliance on technology to improve teaching and learning experiences (Kemp, 2023). With the explosion of digital tools and resources, educators are developing novel approaches to engaging

students, fostering collaboration and personalising instruction. As technology improves and new digital applications emerge, educators must stay educated and adjust their teaching practices to utilise these tools fully. Educators could develop dynamic and inclusive learning environments that educate students about the challenges and opportunities of the digital age by embracing current trends in digital integration (Kemp, 2023).

4.2.5.2 Challenges and barriers for educators when integrating EdTech in teaching practices

Incorporating EdTech in teaching in modern education contexts has become increasingly important. With rapid growth of technology, educators face the issue of adequately incorporating EdTech into their education techniques (Okoye et al., 2021). Despite the potential benefits, however, the integration process faces difficulties. This section investigates the current state of integrating EdTech in teaching and shed light on the major problems educators have to overcome. Understanding these issues will enable educators to devise solutions to overcome them and fully utilise the potential of EdTech to improve teaching and learning results. Furthermore, this section will provide valuable insights into the existing environment of digital integration, to provide an overview of the potential and challenges that lie ahead in education practice.

a) External challenges

Hilton (2022) identifies three first-order hurdles to successfully integrating EdTech in the classroom: access, training, and support. These barriers are primarily caused by external variables beyond the control of lecturers who adopt technology.

- **Access:** Inadequate equipment and connectivity are critical barriers to effective EdTech implementation. As a result, ensuring universal access to the equipment that is essential for running instructional computer applications is the first step towards attaining effective EdTech integration. The inability to access computers every day substantially limits lecturers' ability to integrate EdTech into their lesson plans (Hilton, 2022).
- **Training:** According to Gondwe (2021), professional development and training are the most frequently reported causes of a failure to implement EdTech. Although there is increasing confidence in using EdTech,

operating software and searching the internet, technology is constantly changing. It is, therefore, more important now than ever that lecturers stay updated regarding their technological expertise (Gondwe, 2021). Consequently, the necessary resources must be provided to lecturers so that they can undergo continuous technology training. In addition to the resources, lecturers should have access to specific types of training. Higher education institutions must seek assistance to identify and provide ongoing training to implement EdTech effectively (Erwin & Mohammed, 2022).

- **Support:** Dexter (2023) states that, although we cannot be certain how the future will affect professional development, it is essential that lecturers have access to support for the implementation of EdTech in teaching and learning. With the necessary additional technology support, lecturers can worry less about technological barriers and focus on teaching their students instead. Dexter (2023) explains that the absence of leadership and technical support can lead to a lack of confidence. The primary form of support to lecturers can change as the technology integration project matures. During the earlier phases of a project, lecturers require more technical support to use the new technology, which could be accomplished by hiring educational and information technology professionals. As lecturers become more proficient in the technical skills required for the latest technology, their needs may shift to administrative and peer support to help develop and apply new uses for the technology in their classrooms. This type of support may be provided in professional learning communities through regular discussions on the novel, domain-relevant benefits of the technology (Uzorka et al., 2023).

b) Internal challenges

As Erwin and Mohammed (2022) explain, removing first-order barriers does not guarantee the immediate and seamless integration of EdTech with appropriate pedagogy in all classrooms. Ultimately, individual educators are responsible for utilising technology and, even when provided with resources, they possess the autonomy to make choices regarding its use. These challenges are inherently

personal and vary significantly from one lecturer to another, even within the same education environment. Lecturers' attitudes and beliefs are crucial for determining the role and effectiveness of digital resources and online applications in teaching and learning (Erwin & Mohammed, 2022). Attitudes and beliefs about education technology and pedagogy will ultimately influence how lecturers implement technology (Beans, 2022). Hand in hand with attitudes, confidence about skills and knowledge is also a big challenge to implementing and using digital resources and online applications. Lecturers should feel comfortable and confident about their ability to use digital resources and online applications effectively (Erwin & Mohammed, 2022). Many of the lecturers working today grew up without access to technologies such as personal computers and the internet, while their students were raised in an environment saturated by computer technology (Beans, 2022). These "digital natives" can intimidate lecturers, especially teachers with little technological experience. If lecturers feel they do not have the necessary competencies when using technology, they may feel less in control of the class, use less EdTech, and be unlikely to explore new possibilities that utilise technology when designing their classes (Kaqinari, 2023).

Lecturers' personal teaching philosophies also significantly influence the use of EdTech. If a lecturer regards student learning as primarily dependent on explicit lecturer teaching, classroom activities will be driven by the traditional talk-and-chalk approach (Beans, 2022; Kaqinari, 2023). Less incorporation of computer-based technologies has been linked to attitudes towards education that are more formal. In this case, the use of technology is likely to be restricted to supplemental demonstrative activities for specific academic units. To use technology effectively, lecturers must undergo a paradigm change, from the lecturer-centred classroom to the student-centred classroom (Beans, 2022). Then, education technologies are likely to play a more prominent role, since they encourage active student learning activities in which the teacher facilitates the learning process (Beans, 2022; Kaqinari, 2023).

c) General implementation challenges

EdTech is a highly problematic area when it comes to assessment. Integrating digital resources and online applications in educational assessments presents significant challenges, particularly when traditional "pencil and paper" methods are applied to technology-driven pedagogies (Hilton, 2022). This misalignment often results in

assessments that fail to effectively evaluate competencies central to modern digital learning environments (Hilton, 2022). Despite the prevalence of “digital natives” – students who have grown up immersed in technology – there exist persistent challenges in measuring the communicative and collaborative skills fostered through new technologies (Priya, 2024). Traditional assessment formats may not capture essential competencies such as digital communication, information literacy and teamwork effectively, which raises concerns about the adequacy of current evaluation methods (Priya, 2024). Additionally, some of the digital tools used in education were not originally designed for assessment purposes, which means they have inherent limitations. These tools often lack the features needed to accurately measure complex learning outcomes or may not align with specific pedagogical objectives (Priya, 2024). To address these challenges, there is a growing need to redesign assessment strategies that align with technology-driven pedagogies, selecting appropriate education technologies and enhancing the digital literacy of educators and students. By doing so, institutions can develop more meaningful assessments that reflect the skills required by the digital age.

Funding and equity present complex and entrenched challenges of a dual nature. The degree and intensity of EdTech integration are inextricably linked in finance (Kaqinari, 2023). Many education experts believe that the significant financial burden connected with ICT implementation encourages institutions to pursue a “bring your own device” policy (Kaqinari, 2023). Nonetheless, this method simply shifts responsibility without providing a complete solution to the fundamental problem (Beans, 2022; Kaqinari, 2023). Equity has become a hurdle to integrating EdTech into lecturer pedagogy. Many practitioners believe that EdTech presence as a teaching tool becomes problematic if it is not available to all students.

To implement digital resources and online applications in education in South Africa involves distinct challenges because of the country’s socioeconomic and infrastructural context (Ramorola, 2013). According to Ramorola’s (2013) study on the challenge of effective EdTech integration in teaching and learning, a significant obstacle to implementing digital resources and online applications is the absence of a cohesive policy and well-defined procedures to guide institutions in the implementation process and hinders the seamless integration of EdTech into teaching and learning practices. Recent studies corroborate these findings and indicate that the absence of

clear, context-sensitive objectives and an integrative strategy continues to be a major barrier. For instance, the Department of Science and Innovation (2021) explains that, without well-defined policies, institutions will face difficulties in effectively incorporating ICT in educational frameworks. Similarly, the National Digital and Future Skills Strategy (Department of Communications and Digital Technologies, 2020) acknowledges that the absence of a coordinated approach and structured guidelines complicates technology implementation in educational practices further (Department of Communications and Digital Technologies, 2020). These findings emphasise the need for comprehensive policies and structured frameworks to guide institutions in integrating EdTech into teaching and learning effectively.

Technophobia, as identified by Ramorola (2013), remains a significant barrier to effective EdTech integration in South African education. The term refers to the fear or reluctance of educators to adopt and use EdTech in their teaching practices. Although this issue was noticed over a decade ago, it persists today, with recent studies highlighting similar concerns. Educators often report experiencing anxiety about using new technology, mainly because of their perceived lack of technical knowledge and skills. Many feel overwhelmed by the rapid pace of technological advancements and view themselves as “too old” to effectively master and integrate these tools into their classrooms (Faloye & Ajayi, 2021). The shortage of qualified lecturers specialising in EdTech integration exacerbates the issue, as few individuals are available to guide and support their peers in effectively incorporating EdTech (Ramorola, 2013).

Systemic barriers, such as inadequate equipment, including computers, printers and essential education software, remain significant obstacles to effective technology use. Ramorola’s (2013) observations continue to be relevant today, as limited access to reliable internet and frequent disruptions caused by load shedding hinders the seamless use of digital resources in teaching and learning further. Maintenance issues, insufficient infrastructure and outdated equipment are still widespread and limit the effective deployment of EdTech in classrooms (Mnisi et al., 2024). Connectivity failures, software glitches and limited technical support continue to frustrate both educators and students and disrupt the learning experience.

Furthermore, the complexity of computer jargon and technical terminology creates an additional barrier, as educators unfamiliar with these concepts may struggle to

navigate digital tools confidently (Ramorola, 2013). Addressing these ongoing challenges requires comprehensive, sustained professional development programmes to build up educators' technological skills and confidence. Providing continuous support, improving infrastructure and ensuring access to the necessary resources are essential steps to fostering effective EdTech integration in educational practices (Mnisi et al., 2024; Faloye & Ajayi, 2021).

4.2.5.3 Opportunities for and positive influence on learning outcomes when educators integrate EdTech in teaching practices

In contrast to the challenges identified earlier, this section explores the potential benefits and positive impacts of EdTech integration on learning outcomes (Priya, 2024). Key opportunities include enhancing student engagement, supporting diverse learning styles and preparing students for the digital world. By effectively integrating EdTech, educators can expand instruction possibilities and promote active, student-centred learning (Mireles-Medina et al., 2018).

a) Enhancing student engagement

Incorporating EdTech in lessons can significantly improve the learning experience by creating a more dynamic and adaptable environment. These tools foster creativity, critical thinking, collaboration and problem-solving skills, which are essential for student engagement (Priya, 2024). Digital teaching technologies have evolved to offer a wide range of interactive features that enable students to engage more deeply with the content. For example, integrating digital apps in curriculum areas such as EGD enables lecturers to provide students with relevant and exciting learning experiences, which aligns with teaching objectives (Mireles-Medina et al., 2018). Using EdTech encourages students to participate actively in their education, whether they work independently or collaboratively. Furthermore, EdTech facilitates peer interaction and collaborative learning, even across geographical borders, to make the learning process more engaging and interactive (Mireles-Medina et al. (2018).

b) Supporting diverse learning styles

By catering to diverse learning styles, EdTech offers significant advantages. EdTech enables lecturers to tailor instruction and adapt the content and delivery methods to meet the individual needs of students (Agni et al., 2023). This customisation supports

various learning preferences and makes education more accessible and effective for a broader range of students (Agni et al., 2023). For instance, visual learners benefit from multimedia resources, while kinaesthetic learners can engage with interactive simulations (Agni et al., 2023). Digital tools also provide opportunities for students to work at their own pace by providing opportunities for personalised learning experiences that accommodate different abilities and learning speeds. By leveraging these technologies, educators can diversify their teaching approaches and ensure that all students have the opportunity to succeed, regardless of their preferred learning style (Agni et al., 2023). Additionally, digital applications such as education software and adaptive learning platforms help students gather, evaluate and utilise information effectively and enhance their overall learning experience (Maksimović, 2023).

c) Preparing students for the digital world

One of the most critical benefits of integrating EdTech in teaching and learning is the preparation it provides for students entering the digital workforce. As digital literacy becomes increasingly essential, using common digital tools such as Microsoft Office and Google Suite during the teaching process helps students develop and refine these skills (Hilton, 2022). These applications are frequently used in professional settings, which makes them valuable tools for real-world preparation (Hilton, 2022). By incorporating these resources into the curriculum, lecturers help students gain familiarity with digital tools that they are likely to encounter in their future careers.

According to Hilton (2023), the use of EdTech enables educators to model digital citizenship and responsibility and equip students with the skills they need to navigate the digital landscape effectively. Furthermore, integrating EdTech in teaching provides a foundation for lifelong learning and encourages students to continue developing their digital competencies beyond the classroom (Hilton, 2022).

In summary, while the section on challenges (4.2.5.2) highlights the hindrances and needs for support in EdTech integration, this section on opportunities (4.2.5.3) underscores the transformative potential of EdTech. Enhancing student engagement, supporting diverse learning styles, and preparing students for the digital world are critical benefits of effectively utilising EdTech in education. Embracing these opportunities enables educators to create unique and engaging learning experiences that respond to the evolving demands of the digital landscape. When barriers are

addressed, the seamless integration of digital applications represents a promising frontier in education and can shape the future of teaching and learning in meaningful ways.

4.3 STUDENT-CENTRED LEARNING IN DIGITAL ENVIRONMENTS

In contemporary higher education, there has been a significant shift towards student-centred learning, which has been largely driven by the integration of digital platforms (Habets et al., 2020). This approach positions students as active participants in their educational journey and emphasises personalised learning, critical thinking and skills development tailored to individual needs and preferences (Hilton, 2022). Digital environments play a key role in this transformation by providing versatile tools that facilitate engaging and interactive learning experiences. Instead of being passive recipients, students become active contributors who engage with collaborative and dynamic content that enhances their involvement and ownership of the learning process (Habets et al., 2020). The integration of educational technology, online platforms and interactive tools has expanded access to education while equipping students with essential 21st-century skills, including digital literacy, critical thinking, problem-solving and collaboration. This approach prepares students to navigate and succeed in an increasingly interconnected global landscape (Deacon et al., 2022).

4.3.1 The shift towards student-centred learning in the digital context

The shift towards student-centred learning in digital contexts has accelerated significantly in recent years, driven by the integration of advanced digital platforms and educational technologies (Habets et al., 2020). This approach highlights the active involvement of students in their educational journeys and the way they prioritise personalised learning experiences, critical thinking and skills development tailored to individual needs. Digital environments play a pivotal role in this transformation by enabling students to move from being passive recipients to being active participants. Through dynamic and interactive content, students gain greater engagement and a sense of ownership in the learning process, which fosters deeper involvement and motivation (Habets et al., 2020).

The integration of EdTech, including online platforms and interactive tools, has expanded access to education while equipping students with essential 21st-century skills such as digital literacy, critical thinking, problem-solving and collaboration (Erickson, 2020). These skills are vital for navigating an increasingly interconnected global landscape and preparing students to excel in future professional environments (Deacon et al., 2022). However, implementing student-centred learning in digital contexts presents several challenges. Educators often struggle to adapt to their evolving roles as facilitators of learning, instead of their traditional role as knowledge transmitters. Additionally, ensuring equitable access to digital resources and addressing the digital divide remain significant concerns (Erickson, 2020)

To tackle these challenges, it is essential to provide ongoing professional development for educators and to implement strategic support mechanisms. This help would include creating effective implementation strategies and offering comprehensive training for teaching staff, which can help overcome barriers and enhance the quality of student-centred learning experiences (Green & Parker, 2021). In conclusion, while challenges persist, the shift towards student-centred learning in digital contexts offers substantial opportunities for enhancing education. By effectively leveraging digital tools and platforms, educators can create engaging, personalised and interactive learning experiences that equip students with the skills needed for success in the digital age.

4.3.2 How do Education 4.0 trends support personalised and adaptive learning experiences?

As discussed in Section 4.3.1, personalised and self-paced learning approaches allow students to progress at their own speed and foster a deeper understanding and mastery of the subject matter. Recent developments in Education 4.0 have supported this shift further, by emphasising the integration of adaptive systems and technologies to enhance the educational experience (Rane et al., 2024). By utilising sophisticated information and computing technologies, educators can now precisely identify and analyse students' unique learning styles, behaviours, strengths and areas needing improvement (Rane et al., 2024). This personalised approach allows for more targeted feedback and tailored learning experiences.

The trends of Education 4.0 extend beyond personalised learning by incorporating adaptive systems that are capable of adjusting to student progress in real time. This

adaptive technology improves the efficiency and effectiveness of the educational process and provides immediate feedback and continuous monitoring of student performance (Al-Ababneh & Alrhaimi, 2020). One of the primary benefits of adaptive learning platforms is their capacity to provide instant feedback. This meets the strong desire of students to receive timely responses to their work, because adaptive systems continuously monitor progress and adjust the difficulty of content based on individual needs (Taylor et al., 2022). When students demonstrate a strong grasp of a concept, the system advances them to more challenging material; conversely, when students struggle, the system offers additional resources and support to help them build a solid foundation before moving on (Taylor et al., 2022).

Adaptive learning systems use machine learning algorithms to analyse extensive datasets, uncover trends and identify students at risk of falling behind. By identifying potential learning gaps early on, these systems can offer targeted interventions and ensure that all students receive the support they need to succeed (Rane et al., 2024). The ability to tailor content and pace based on real-time data enhances the learning experience and increases student success rates. Furthermore, adaptive systems provide educators with daily reports and analytics and offer valuable insights into individual learning patterns. This enables educators to adjust their teaching strategies effectively and enhance the overall educational experience (Al-Ababneh & Alrhaimi, 2020).

Education 4.0 trends support educators by automating administrative tasks and freeing up time for teaching and student engagement. For instance, adaptive learning platforms can automate grading, monitor student progress and identify areas where students need additional support, thereby streamlining the teaching process and enabling greater focus on lesson planning and interactive activities (Taylor et al., 2022). Additionally, the use of learning analytics provides educators with data-driven insights into the effectiveness of their teaching methods. By analysing student performance data, educators can make informed decisions to refine their instructional strategies and improve learning outcomes (Rane et al., 2024).

The trends of Education 4.0 promote customised and adaptive learning experiences through the integration of advanced technologies such as learning analytics and machine learning. These innovations enable educators to personalise learning

pathways, offer immediate feedback and continuously assess student progress (Taylor et al., 2022). Adaptive systems dynamically adjust content and pacing to meet individual student needs, thereby maximising their likelihood of success. While challenges remain in implementing these technologies, the potential of Education 4.0 to revolutionise the educational landscape and enhance student achievements is promising.

In conclusion, Education 4.0 focuses on creating tailored and adaptive learning experiences by utilising advanced technologies to meet the diverse needs of individual students. This innovative approach enhances the quality of education and prepares students with essential skills for future career success. Effective implementation of student-centred learning in digital contexts requires ongoing research, continuous professional development for educators and the adoption of evidence-based practices. These strategies will help ensure that education processes remain efficient, impactful and aligned with contemporary learning needs.

Section 4.4 contextualises Education 4.0 in the EGD module at the case study university. It explores how integrating EdTech aligns with Education 4.0 principles and can enable a more interactive and student-centred approach that is tailored to the specific learning needs of EGD students.

4.4 CONTEXTUALISING EDUCATION 4.0 IN THE EGD MODULE AT THE CASE STUDY UNIVERSITY WHEN INTEGRATING EDUCATION TECHNOLOGY

The presentation of the EGDC1614 module at the case study university aligns with the principles of Education 4.0 (Faculty of Education, University of the Free State, 2023), the student-centred focus of Vision 130 (of the host university of this case study, the University of the Free State), and the framework of universal design for learning. Education 4.0 highlights the integration of advanced technologies, adaptive learning methodologies and the facilitation of personalised and self-paced educational experiences that are specifically tailored to meet the diverse needs of students (Taylor et al., 2022). This approach aligns with the dedication of Vision 130 to fostering academic excellence and cultivating graduates who are competitive on a global scale (Faculty of Education, University of the Free State, 2023).

The EGD module encompasses fundamental units that cover basic principles, freehand sketches, orthographic projections and assembly drawings. The integration of digital tools, in conjunction with the principles of universal design for learning, effectively addresses a variety of learning styles, thereby improving both accessibility and engagement in the module. This approach is consistent with the university's objective of promoting a research-oriented, student-focused environment, thereby providing students with essential skills in graphic communication and problem-solving.

4.4.1 Exploring EdTech applications and resources in teaching and learning EGD

The dynamic terrain of education has experienced substantial modifications in the domain of EGD, which have been spurred mainly by the integration of EdTech. This paradigm change has paved the way for many tools and resources that provide unique ways to improve teaching and learning experiences. The convergence of EdTech and EGD has opened up new frontiers for educators and students alike, ranging from innovative software programmes to online resources.

According to the CAPS FET document for EGD, a key objective is to incorporate CAD as a drawing method (Department of Basic Education, 2021). Consequently, traditional drawing and design knowledge alone is no longer sufficient for EGD. Instead, modern EGD education requires the integration of innovative teaching methodologies that enhance student abilities to understand both basic and advanced design concepts. Interactivity, visualisation and animation have become vital components of innovative teaching methodologies and significantly enhance the learning experience (Garcia-Peñalvo & Colomo-Palacios, 2015). With the support of the internet, these tools can be widely disseminated to provide global access to dynamic educational content. Animations, in particular, have been shown to be more effective than static images because they offer clearer explanations of complex systems and positively affect student engagement and comprehension (Colomo-Garcia-Peñalvo & Colomo-Palacios, 2015).

By incorporating various communication tools, interaction is facilitated between the lecturer and students and information can be conveyed more effectively (Deacon et al., 2022). This approach reduces the time required to cover theoretical content, freeing up time to do additional tutorials and enriching the learning experience. The

availability of self-explanatory digital resources that are accessible at any time and anywhere, brings students closer to a better understanding of the material. The extensive use of ready-made graphics helps them to visualise concepts and make them more comprehensible to students (Deacon et al., 2022).

Creating and implementing innovative teaching methodologies, including EdTech, are essential for creating CAD drawings and static images. EdTech also features specialised applications for generating computer animations and video presentation tools for developing audiovisual demonstrations of the subject matter (Garcia-Peñalvo & Colomo-Palacios, 2015). Central to innovative teaching methodologies is the integration of an LMS or a dedicated website, which serves as the primary platform for effective teaching and learning (Deacon et al., 2022).

4.4.1.1 *Creating CAD drawings and static images*

The demand for CAD arose when the complexity of the world outpaced traditional design capabilities. The design process, which had already been challenging, became increasingly demanding with the introduction of sophisticated technologies integral to modern design (Voelkl et al., 2020).

Numerous CAD software programmes are available for generating EGD drawings. Some of the most widely recognised and commonly used CAD applications are listed in Table 4.1.

Table 4.1: Widely recognised and commonly used CAD software for EGD

EdTech	Definition
ArchiCAD Gaha et al. (2021)	As a building information modelling software developed by Graphisoft, ArchiCAD is used for creating detailed 2D and 3D architectural designs. It supports collaborative workflows in the architecture, engineering and construction industries.
AutoCAD Gaha et al. (2021)	Developed by Autodesk, AutoCAD is among the most widely used CAD software in the industry. It offers a comprehensive suite of 2D and 3D drafting, modelling, and documentation tools, making it well-suited for EGD applications.

EdTech	Definition
Autodesk Inventor Erickson (2023)	This software is frequently used for mechanical design and engineering tasks, offering advanced 3D solid modelling and visualisation tools.
DraftSight Garcia-Peñalvo and Colomo-Palacios (2015)	As an affordable alternative to AutoCAD, DraftSight is a 2D drafting software that is suitable for simpler EGD projects and drawings.
FreeCAD Garcia-Peñalvo and Colomo-Palacios (2015)	As an open-source CAD programmes that is free of charge, FreeCAD provides both 2D and 3D modelling capabilities, which makes it a cost-effective option for EGD work.
OnShape Marion et al. (2021)	This cloud-based CAD software enables collaboration and remote access, which makes it ideal for teams working on EGD projects from different locations.
SketchUp Gaha et al. (2021)	Developed by Trimble Inc., SketchUp is a 3D modelling software that is widely used for designing and developing models of objects, buildings and landscapes. It is known for its user-friendly interface, which makes it accessible for both professionals and beginners.
SolidWorks Gaha et al. (2021)	Known for its powerful 3D modelling capabilities, SolidWorks is extensively used in mechanical engineering and product design. It is also effective for producing complex EGD drawings.
TurboCAD IMSI/Design, (n.d.)	Created by IMSI/Design, LLC, TurboCAD is a versatile CAD application that is used in various disciplines, including architecture, engineering and mechanical design. It supports the creation of precise and detailed 2D and 3D drawings.

In selecting the appropriate CAD software various factors must be considered, such as project complexity, required features, budget constraints and industry standards. Each software has distinct strengths and is tailored for specific purposes; therefore, it is important to make a decision based on the unique needs of particular EGD projects (Garcia-Peñalvo & Colomo-Palacios, 2015).

4.4.1.2 *Generating computer animations*

To enhance EGD teaching, several advanced animation software programmes are available that help educators create engaging visual content, simplify complex concepts and demonstrate mechanical movements effectively. Among the most popular options is Blender, an open-source 3D animation suite known for its comprehensive tools for modelling, rigging, animation and rendering, which makes it ideal for intricate animations and visualisations (Hilton, 2022). Another notable choice is Autodesk Maya, a powerful 3D animation and modelling software widely used in various industries, including education, because of its advanced animation capabilities and support for diverse rendering techniques (IMSI/Design, n.d.). Cinema 4D is recognised for its user-friendly interface and extensive 3D animation features, which makes it a preferred tool for creating instructional motion graphics and visual effects (Priya, 2024).

For 2D animations, Adobe Animate – formerly known as Flash – provides a versatile platform for creating interactive multimedia; it is suitable for producing educational animations and graphics (Green & Parker, 2021). Additionally, Toon Boom Harmony offers powerful tools for hand-drawn and digital animations and emphasises artistic expression and engaging content creation (Hilton, 2022).

When choosing animation software for EGD education, factors such as ease of use, animation complexity, compatibility with other tools and the availability of tutorials and support resources should be considered.

4.4.1.3 *Video presentation applications*

Various video presentation software programmes are available for creating compelling and interactive video content for teaching EGD. These technologies enable instructors to explain concepts, display designs and deliver instructional information in an engaging and visually appealing manner. In Table 4.2, some prominent video presentation software alternatives for EGD teaching are listed.

Table 4.2: Popular video presentation software for teaching EGD

EdTech	Definition	EGD application
Audacity Audacity Team (2023)	A free, open-source, cross-platform audio software that functions as a multi-track audio editor and recorder. It enables users to record live audio, edit sound files, apply various effects and mix tracks. Supports a wide range of audio formats	Can enhance instructional content by enabling educators to create audio narrations for complex tutorials and improve clarity and engagement. Students can use Audacity to add audio explanations to their design presentations to effectively convey their design choices and processes, thus supporting a deeper understanding of EGD concepts.
Adobe Spark Video Adobe (2023)	A user-friendly application designed for creating engaging video stories by combining video clips, photos, text and music	An effective tool for creating dynamic presentations that visually explain complex concepts, demonstrate design processes and showcase project outcomes, thereby enhancing student comprehension and creativity.
Articulate Storyline Articulate (2023)	A robust e-learning authoring tool that enables users to create interactive and engaging online courses. It offers features such as slide layers, triggers and states, which allow for the development of complex interactions and assessments	Can be used to develop interactive tutorials and assessments. Enables students to practise drawing techniques in a virtual setting, receive immediate feedback and engage with dynamic content to enhance their understanding of complex concepts.
Camtasia TechSmith (2023)	A versatile screen recording and video editing software developed by TechSmith, designed to help users create professional-quality videos with ease	An effective tool for creating detailed tutorials, software demonstrations, and project presentations. Educators can use it to illustrate complex concepts and design processes, while students can document their projects and develop engaging video content that showcases their skills and understanding of EGD.
CapCut	A free, user-friendly video editing application developed	CapCut enhances EGD by creating tutorials, animating

EdTech	Definition	EGD application
ByteDance Ltd. (n.d.)	by ByteDance. It is popular for its versatile features that allow users to create professional-quality videos on mobile devices or desktops.	mechanisms, showcasing student work, providing video feedback and helping students build design portfolios with sketches, CAD files and prototypes.
FeedbackFruits FeedbackFruits (2023)	An educational technology platform that offers a range of tools aimed at enhancing teaching and learning through active learning, peer feedback and collaborative activities. Integrated in LMSs	Supports a student-centred approach by facilitating peer reviews and group evaluations. Students can use these tools to provide and receive constructive feedback on their design projects and foster critical thinking and collaborative skills to, ultimately, enhance project quality and understanding of engineering concepts.
Loom Loom (2023)	A video messaging platform that allows users to easily record and share videos of their screen, voice, and webcam, thereby supporting efficient asynchronous communication	Loom can be an effective tool in EGD for creating instructional videos, showcasing design processes, or providing software tutorials. Educators can use it to explain complex concepts visually, while students can present their projects and receive feedback to foster a more interactive and engaging learning environment.
Open Broadcaster Software (OBS) OBS Studio (2024)	A free, open-source application designed for video recording and live streaming. It enables users to capture and mix high-quality audio and video in real time. Supported by various sources such as screen captures, webcams and multimedia files	Can be effectively used by educators of EGD to create comprehensive tutorials, software demonstrations and project critiques. Students can also utilise OBS to record and present their design projects and enhance engagement and providing a platform for feedback, which supports a deeper understanding of EGD concepts.
OpenShot OpenShot (n.d.)	A free, open-source video editing software compatible with Linux, Mac, and Windows, that features a user-friendly interface and comprehensive tools for editing video, audio, and images	Can be effectively used by educators to create instructional videos and software tutorials, thereby enhancing the teaching of complex design processes. Students can use OpenShot to

EdTech	Definition	EGD application
		present their projects and integrate multimedia elements to clearly convey their design ideas and concepts, thereby improving engagement and understanding.
Powtoon Powtoon (2023)	A cloud-based animation software designed for creating animated presentations and explainer videos and featuring an intuitive interface that integrates multimedia tools and digital storytelling elements	A valuable tool for developing engaging visual content that simplifies complex engineering concepts. Educators can create animated sequences to demonstrate mechanical movements and design principles, while students can use the platform to present their projects creatively and enhance understanding and engagement.

The wide variety of video presentation software offers significant advantages for teaching and learning in EGD. These tools enable educators to present complex concepts dynamically, demonstrate design processes and create engaging instructional materials. Applications such as Adobe Spark Video provide user-friendly storytelling features, while Camtasia offers robust screen recording capabilities and Articulate Storyline supports interactive course creation. Tools such as Powtoon and FeedbackFruits promote creativity and collaboration, while platforms like OBS Studio, OpenShot and Audacity offer comprehensive video editing and audio narration features. By integrating these technologies, educators can deliver visually appealing content, cater for different learning styles and enhance students' understanding of EGD principles.

4.4.1.4 *Presentation applications*

Presentation programmes have sparked widespread discussions, particularly in higher education. Numerous studies have explored students' reactions and preferences for PowerPoint presentations and evaluations of students' performance when using these tools (Gupta, 2023). There is also abundant advice on creating effective PowerPoint slides and discussing tips for teachers when making presentations in the classroom. The influence of these programmes on higher education continues to be a subject of

interest and research, shaping how educators engage and deliver content to their students (Elsakova et al., 2019). Some popular options are described in Table 4.3.

Table 4.3: Presentation applications for teaching EGD

EdTech	Definition	EGD application
Explain Everything Explain Everything (2023)	An interactive whiteboard application that enables users to create dynamic presentations by combining drawings, text, images, videos, and audio, with support for real-time collaboration	Can enhance teaching of EGD by enabling educators to visually demonstrate complex engineering concepts and design processes. The recording and replay features enable students to review lessons independently, and its collaborative tools foster teamwork on design projects and supports essential engineering skills.
FeedbackFruits FeedbackFruits (2023)	An educational technology platform that offers a range of tools aimed at enhancing teaching and learning through active learning, peer feedback, and collaborative activities, integrated within LMSs	Can support a student-centred approach by facilitating peer reviews and group evaluations. Students can use these tools to provide and receive constructive feedback on their design projects to foster critical thinking and collaborative skills, thereby ultimately enhancing project quality and understanding of engineering concepts.
Google Slides (2023)	Free of charge, web-based presentation software developed by Google that enables users to create, edit and collaborate on presentations online. Features real-time collaboration and integration with Google Workspace tools	Can be effectively used by educators to create interactive presentations that incorporate diagrams, images and videos to aid in the explanation of complex concepts. Its collaborative features enable students to work together on projects and enhance peer learning and teamwork, while the cloud-based access ensures flexibility and availability of learning materials.
Keynote Apple (2023)	A presentation software that features animations, transitions and multimedia integration	Enables educators to visually explain complex concepts and helps students create engaging presentations to communicate design ideas effectively.

Microsoft PowerPoint Microsoft Support (2022)	A widely used presentation software developed by Microsoft that enables users to create dynamic presentations with text, graphics, animations and multimedia elements	An effective tool for visually demonstrating complex EGD concepts. Educators can use slides, animations and videos to illustrate design stages, mechanical movements and transformations to enhance student understanding and engagement.
Nearpod Nearpod (2023)	An interactive education platform that enables educators to create and deliver engaging lessons with multimedia elements, assessments and collaborative activities to enable real-time student participation and immediate feedback	Can help EGD educators incorporate 3D models, simulations and quizzes to explain complex concepts and enhance student engagement. Its real-time feedback features enable instructors to assess comprehension and adapt instruction accordingly to promote a deeper understanding of design principles.
Prezi Prezi (2023)	A cloud-based presentation software that enables users to create dynamic, non-linear presentations using a zoomable canvas. Offers an interactive storytelling experience with multimedia integration	Can be a valuable tool for illustrating complex engineering concepts and design processes. Educators can use its zooming capability to highlight specific details or provide an overview of entire systems to improve student comprehension. Students can also use Prezi to present their projects interactively, enhance their presentation skills and foster deeper engagement with design concepts.

Presentation software has become an essential tool in higher education, particularly in fields such as EGD, where visual and interactive elements are crucial for student understanding. These tools enable educators to present complex concepts in engaging ways, combining visual and interactive elements to aid comprehension. Additionally, many of these platforms support collaborative learning and peer engagement, allowing students to interact with content and one another, which enhances both understanding and retention. As research and discussions around these tools continue to expand, the influence of presentation software on higher

education remains substantial, adapting to meet diverse instructional needs and making the educational experience more interactive, flexible and effective.

4.4.1.5 *LMS or a dedicated website*

An LMS or dedicated website is crucial for effective teaching and learning in EGD, as it provides a streamlined platform for managing complex content such as technical drawings and design concepts. A well-integrated LMS serves as a central hub to which lecturers can upload course materials, lecture notes and additional resources that are accessible to students at any time, thereby enhancing their ability to review content at their own pace and revisit challenging topics when needed (Kristin & Lillejord, 2024).

Furthermore, LMS platforms foster interactive and collaborative learning through features such as discussion boards and messaging systems, which enable students to engage in academic discussions and seek guidance from peers and instructors (Fibriasari et al., 2023). These platforms also support assessment through quizzes, assignments and evaluations and give instructors critical insight into student progress and areas that may need additional support (Fibriasari et al., 2023).

In the context of EGD, a dedicated website or LMS can provide access to specialised tools and software that are essential for developing technical drawings and designs and which are accessible from anywhere with an internet connection. Combining asynchronous tools, such as recorded lectures and resources, with synchronous features, such as real-time text, audio and video interactions, provides both flexibility and immediate engagement, caters for diverse learning preferences and enhances the overall learning experience (Priya, 2024).

Incorporating an LMS or dedicated website in EGD education empowers lecturers and students by creating a cohesive, accessible and flexible learning environment and ultimately leads to a more efficient and enriching educational experience.

4.4.2 Innovative assessment approaches: Online quizzes, peer assessments and automated grading in EGD education

In the dynamic field of EGD, adopting innovative assessment methods is essential for effectively evaluating student learning and development. Traditional evaluation techniques often fall short of capturing the diverse skills required in EGD. By

integrating online assessments such as online quizzes, peer assessments and automated grading systems, educators can implement a comprehensive and interactive assessment approach that enhances both learning and teaching (Pradana, 2023).

4.4.2.1 *Online quizzes*

Online quizzes provide a flexible and efficient way to assess students' knowledge and understanding of EGD education. They can measure a range of skills, from theoretical comprehension to practical application. According to Babo et al. (2020), online quizzes offer immediate feedback, thereby enabling students to quickly identify their strengths and areas needing improvement. This timely feedback helps students focus their efforts more effectively and supports their learning process. Moreover, the accessibility of online quizzes accommodates diverse student schedules and learning paces and makes them a versatile tool for assessment (Babo et al., 2020).

4.4.2.2 *Peer assessments*

Peer assessments involve students in evaluating each others' work. It fosters critical thinking and self-reflection and promotes a deeper understanding of the subject matter. Mumpuni et al. (2022) found that peer assessment enhances learning outcomes by developing students' abilities to provide and receive constructive feedback. This process not only helps students improve their work through peer input but also cultivates the skills they need to critically analyse and evaluate design projects – an essential competency in EGD. Additionally, peer assessment promotes a collaborative learning environment by exposing students to diverse perspectives and ideas that can inspire creativity and innovation in their designs.

4.4.2.3 *Automated grading systems*

Automated grading systems use algorithms to assess student work and deliver immediate feedback and grades. In EGD education, where precision and accuracy are critical, automated grading ensures consistent and objective assessments (Babo et al., 2020). Automated grading systems efficiently manage large volumes of student work to free up time for educators to provide personalised instruction and support. Additionally, automated grading reduces human error and bias and ensures fair evaluations for all students. These systems also provide detailed analytics on student

performance and enable educators to identify trends and adjust their teaching strategies to better meet student needs (Babo et al., 2020).

Incorporating innovative assessment approaches such as online quizzes, peer assessments and automated grading systems can greatly enhance the evaluation process in EGD education. These methods provide immediate and constructive feedback, foster critical thinking and collaboration and ensure consistent and objective grading (Babo et al., 2020). By integrating these tools, educators can create a dynamic and interactive learning environment that better prepares students for the demands of the EGD industry.

4.5 CONCLUSION

This chapter addressed the third subsidiary question (see Section 1.4.2): What are the critical trends in Education 4.0 for applying EdTech in EGD online learning and teaching? By introducing Education 4.0 as a transformative era, this chapter redefined the dynamics of online learning and teaching through EdTech integration (see Section 2.2). It also emphasised the significance of TPACK (see Chapter 2) in digital contexts, exploring key trends in Education 4.0 (see Section 4.2), core characteristics (see Section 4.2.1), and the advantages and challenges associated with these advancements (see Section 4.2.2) in online education settings. This section also underscored the digital literacy skills needed by both educators and students in the Education 4.0 era (see Section 4.2.3) and, thereafter, examined the future potential of EdTech in teaching by focusing on innovation and implications for higher education (see Section 4.2.4). Furthermore, the present state of EdTech was discussed by addressing challenges, barriers, opportunities and positive influences on learning outcomes (see Section 4.5.2).

In the evolving landscape of higher education, the role of EdTech in EGD underpins a transition to student-centred learning (see Section 4.3) in digital environments, thereby illustrating the impact of Education 4.0 on pedagogical approaches. This chapter also analysed how Education 4.0 trends promote customised and flexible learning experiences to meet diverse student needs, as discussed in Chapter 3.

In conclusion, this investigation examined innovative assessment approaches in EGD – peer evaluations, online tests and automated grading – to align with Education 4.0

principles to support a modern, effective evaluation system that fosters skills development and engagement. Education 4.0 has revolutionised education by eliciting technological advancements that redefine how knowledge is imparted and acquired and enabling personalised, adaptive learning and heightened student engagement through digital resources and assessments.

The following chapter, Chapter 5, will delve into the research methodologies employed in this study to investigate the influence of Education 4.0 on EdTech integration in EGD. This methodological chapter is necessary for understanding the detail of the methods used for data collection and analysis and offers insights into the influence of EdTech on the evolving landscape of higher education.

CHAPTER 5

RESEARCH METHODOLOGY

5.1 INTRODUCTION

As indicated in the previous chapters, incorporating technology (specifically, EdTech) into online learning and teaching practices (in this case, in the EGD module of this study) is a complex task that requires a comprehensive grasp of diverse knowledge domains. As a result, the TPACK framework (see Section 1.3 and Chapter 2) was utilised to navigate the complex challenges associated with integrating EdTech into online learning and teaching practices, emphasising the multifaceted nature of this task.

This chapter is reserved for the methodological aspects (see Section 1.5) of this empirical higher education doctoral study, to demonstrate how the research was implemented. Thus, the chapter establishes the foundation of the study by detailing the research methodology (see Section 5.3), outlining the overall research approach (see Sections 1.5.1 and 5.3) and explaining the design (see Sections 1.5.2 and 5.4) used to collect and analyse data. These methodological choices were crucial for addressing the research questions and achieving the study objectives (see full details in Chapter 7).

In this chapter, I describe and justify the research methodology of this study (see Section 1.5) to address the main research question (see Section 1.4 and Table 5.1). To answer this research question, this study followed a qualitative approach that was complemented with quantitative elements, as depicted in Table 5.1. Additionally, the study focused on a pragmatic education design that used a HyFlex teaching and learning method (see Appendix G) to teach EGD (the EGDC1614 module) to student teachers. This inquiry (see Section 1.5.1) collected data from first-year EGD student teachers at the case study university (see Appendices E and F). In this study, the qualitative data contextualised and provided deeper insights into the quantitative results of the data on first-year EGD students; it explains why certain outcomes occur when EdTech is integrated into EGD and offers insights into the 10-week practical intervention (see Appendix H). Furthermore, triangulation was achieved with qualitative data from lecturers' self-reflections.

Table 5.1 provides a comprehensive overview of the research methodology and design, by detailing the systematic approach adopted for data collection, analysis and interpretation by this study. It is crucial to refer to Table 5.1 throughout this chapter, because it summarises the mainly qualitative approach that was complemented by a quantitative research approach.

Table 5.1: Outline of the research methodology and design

Research study topic A TPACK perspective on integrating Educational Technology (EdTech) for EGD student teachers	
Research question	How can a technology education lecturer use a TPACK perspective to integrate EdTech for EGD first-year student teachers' online learning and teaching?
Research paradigm (see Section 5.2 for full details)	
Ontology	In this study, on integrating EdTech in first-year EGD online learning and teaching, the <i>pragmatic ontology</i> asserts that reality is dynamically shaped by actions and experiences, by focusing on evaluating the practical effectiveness and outcomes of educational tools and methods to ensure they meet real-world needs (see Section 5.2 for full details).
Epistemology	A <i>pragmatic epistemological stance</i> (see Section 5.2 for full details) is a perspective on knowledge and understanding that emphasises practicality and applying knowledge in real-world contexts (Holtrop & Glasgow, 2020). Therefore, the focus of TPACK on real-world applications and context-specific solutions emphasises practical outcomes and aligns with constructivist principles by empowering teachers as facilitators who create meaningful learning experiences, thereby positioning TPACK firmly in a pragmatic paradigm.
Methodology	Methodology encompasses the comprehensive planning and application of this pragmatic education research design that involved a 10-week intervention-based, HyFlex teaching and learning method, with a qualitative approach complemented by a quantitative approach, and a single-case study strategy for an exploratory investigation, which guided the researcher in gathering data and insights needed to answer research questions and achieve objectives (see Section 5.2 for full details).
Axiology	Axiology addresses the ethical considerations (see Section 1.8) in research planning, particularly regarding participants and data (see Section 5.2 and Appendix C for full details) and emphasises principles of privacy, accuracy, property and accessibility, as highlighted by Kivunja and Kuyini (2017).

Pragmatic inquiry: Evaluation education research design (10-week intervention-based TPACK and TIM levels)		
Case study strategy		
A case study research strategy was initially assumed to meet the in-depth and exploratory needs of the research, as it was focused on the first-year EGD module		
Case study strategy	Single, exploratory case study (see Sections 1.5.3)	EGDC1614 module (n = 1)
Selection of participants: Total population sampling is a type of purposive sampling that was applied in this research because of the small sample size (see Section 5.6)	Purposive selection of first-year EGD student teachers (see Sections 1.5.3.2 and 5.6)	Male (n = 10) Female (n = 9) Total number (Nn = 19)
	Volunteers	First-year EGD lecturer, (researcher), male (N = 1) Second-year EGD lecturer, male (N = 1) Total number (N = 2)
Data collection		
Data collection method: Qualitative (all instruments), with complementing quantitative elements of data (only related to the two online questionnaires, 1 and 2) through a case study strategy	• Online pre-intervention questionnaire (see Appendix D for first-year EGD student teachers) • Online post-intervention questionnaire (see Appendix E for first-year EGD student teachers) • Questionnaire 3 (see Appendix F for the lecturer of EGDC2714 module – second year students) • Classroom observation (see Appendix G, focused on the self-reflection)	
Data analysis		
Data analysis	Qualitative: Content and thematic analysis Quantitative: Descriptive statistics Self-reflection – Six levels of reflection of Gibbs (McLeod, 2024)	
Quality measures		
Quality criteria	Triangulation Trustworthiness Credibility Dependability Confirmability Transferability	

Ethics considerations		
Ethical issues	Ethics clearance No. UFS-HSD2022/2066	University permission Student consent and approval Lecturer consent and approval Ethics form Confidentiality and anonymity Vulnerable participants Power relationship Beneficiation, reciprocity and remuneration Privacy, security and technology risks

As illustrated in Table 5.1, this research study adopted a comprehensive approach to explore the integration of EdTech in the context of first-year EGD student teachers through a TPACK perspective, by employing a pragmatic research paradigm that emphasises the practical application of knowledge in real-world educational settings. Additionally, the study focused on the dynamic interplay of ontology, epistemology, methodology, axiology and ethics considerations in the framework of a 10-week intervention-based case study strategy. The research aimed to rigorously evaluate the effectiveness and outcomes of technology integration in online learning and teaching. Through careful data collection and analysis, this study aspired to contribute valuable insights that could inform best practices in the use of EdTech, ultimately enhancing the educational experiences of both teachers and students in the evolving landscape of digital education, with special reference to a particular EGDC1614 module.

5.2 RESEARCH PARADIGMS

Researchers in diverse academic disciplines often hold contrasting views regarding the nature of research and the relationship between research and the knowledge generated within their fields. Research paradigms, therefore, represent the underlying beliefs and assumptions that shape and inform research (Kivunja & Kuyini, 2017; Ulz, 2024). In the context of education research, the term paradigm is used to characterise a researcher's "worldview" (Mackenzie & Knipe, 2006). This worldview encompasses the perspectives, theories, schools of thought and shared beliefs that guide the interpretation of research data, influence decision-making and determine research

methodology, thereby aligning with the foundational concepts proposed (Guba & Lincoln, 1994).

Paradigms are essential for directing researchers' understanding of key aspects of reality, the nature of knowledge and the methodologies utilised to acquire that knowledge. These paradigms consist of four elements, namely ontology, epistemology, methodology and axiology, each of which significantly affects research design and is vital for upholding the integrity of a study (Jackson, 2022;). According to Guba and Lincoln (1994), Kivunja and Kuyini (2017) and Moon and Blackman (2017), these three components of paradigms can be described and applied in the context of a study, to the case of this study, as follows:

- **Ontology** refers to the nature of reality and what is considered to exist in reality. In the context of this study, on integrating EdTech within EGD online learning and teaching, the ontology was pragmatic, grounded in the belief that change is inevitable and that reality is shaped by actions, experiences and their outcomes. I focused on evaluating the effectiveness of tools, methods and approaches in real-world contexts to ensure they address practical needs. For me, truth lies in what works in practice, which emphasises the importance of assessing and reflecting on teaching and learning innovations to determine their efficacy and relevance.
- **Epistemology** concerns the nature, scope and justification of knowledge – what we know and how we know it. Thus, epistemology “focuses on the nature of human knowledge and comprehension that you, as the researcher, can possibly acquire so as to be able to extend, broaden and deepen understanding in your field of research” (Kivunja & Kuyini, 2017, p. 27). In this study, I adopted a pragmatic epistemological stance by emphasising practical knowledge and real-world solutions. By gathering concrete, practical data through a 10-week intervention (i.e., experimental method), I aimed to explore the effectiveness of EdTech integration for training EGD first-year students in higher education. This approach focused on authentic, hands-on experiences to uncover new insights and to address practical challenges. TPACK as theoretical framework (see Section 1.3 and Chapter 2) – not confined to a single paradigm but primarily grounded in pragmatic paradigm – reflects its focus on the practical integration

of TK, PK and CK to enhance teaching effectiveness. TPACK emphasises real-world applications and prioritises context-specific solutions and practical outcomes. It also aligns with constructivist principles by supporting the role of teachers as facilitators who design meaningful learning experiences through the interplay of its core components. In these ways, the adaptability and focus of TPACK on utility place firmly it in a pragmatic paradigm.

- **Methodology** explains how we find out about things. Thus, methodology, holistically, refers to the “research design, methods, approaches and procedures” that are systematically planned and applied in an explorative investigation (Kivunja & Kuyini, 2017, p. 28). For example, data gathering, participants, instruments used and data analysis are all parts of the broad field of methodology as illustrated in Table 5.1. In addition, the researcher should ask the question, How shall I go about obtaining the desired data, knowledge and understandings that will enable me to answer my research question, reach my objectives and, thus, make a possible contribution to knowledge?
- **Axiology** refers to the issues related to ethics that need to be considered when planning research, with special reference to dealing with participants and data. Four principles highlighted by Kivunja and Kuyini (2017, p. 28) relate to privacy, accuracy, property, and accessibility.

This integrative approach to the four elements of paradigms highlights the significance of understanding how different paradigms shape both the theoretical and practical dimensions of research and influences outcomes and interpretations across diverse fields of study. Consequently, the emphasis now shifts towards justifying the methodological decisions applied in this study.

5.3 RESEARCH METHODOLOGY

This study utilised an interdisciplinary qualitative research approach with quantitative elements (see also Section 1.5.1) to investigate the integration of EdTech in teaching and learning for first-year EGD students, with the aim of developing guidelines for educational technology lecturers. The strength of this approach lies in combining perspectives from both the fields of educational technology and higher education. The primary objective of this interdisciplinary method is to tackle complex, real-world

problems by providing a range of perspectives on effective solutions (Davidoff & Jayusi, 2024). In this context, the emphasis was on enhancing the integration of EdTech in the teaching and learning processes of first-year EGD student teachers. This emphasis enabled the researcher to address the research questions effectively and accurately (Saunders et al., 2019).

This study focused on how EdTech can be integrated into online learning and teaching of first-year EGD student teachers through a TPACK lens by incorporating student engagement while considering the prompt technological advancements and the effects of the 4IR (see Section 1.2). The research question that arose to address this situation is, How can higher education respond to ensure online learning and teaching remain relevant for the diverse learning styles and instruction method preferences of first-year students? At the same time, it was essential to address the challenges of the “new normal” brought about by COVID-19 while also considering the demands of the 4IR (see Section 1.2). Thus, the research (see Section 1.2) explored the possibilities of making online learning and teaching relevant for the students of today, by inviting them into the online world of technology education through online, open-source applications and digital technology.

In this study, I actively participated in designing the teaching and learning materials that were presented for 10 weeks. The students were actively engaged with these EdTech and EGD materials and resources through technology integration (Shaw et al., 2018) during lessons. The five levels of technology integration of Shaw et al. (2018) in education settings are the following:

- **Entry:** Technology is used to deliver curriculum content, which is directed by the teacher, with passive student involvement.
- **Adoption:** Technology tools are used conventionally. Students begin to use technology more independently under the teacher's direction.
- **Adaptation:** Technology is integrated into the classroom, and students use it independently and collaboratively as a regular part of learning.
- **Infusion:** Technology becomes a seamless tool in daily routines and activities, with students selecting tools that best meet their needs.

- **Transformation:** Technology is used innovatively to support and enhance learning, thereby enabling students to create, collaborate and solve problems in ways not possible without technology, thereby transforming the learning environment and roles of both teachers and students.

In this study, a qualitative approach was employed, with some quantitative questions asked to investigate the incorporation of EdTech resources. By combining numerical data with experiential insights, this approach leveraged the strengths of both paradigms and offered a more comprehensive and nuanced understanding of the research problem.

To supplement this approach, qualitative questions were used to capture the depth and richness of participants' experiences with EdTech resources. This approach enabled the researchers to explore the motivations, challenges and personal influences experienced by participants, to add a human dimension to the numerical findings. This methodological synergy is particularly valuable in complex research areas where both statistical trends and individual experiences are crucial for a full comprehension of the subject matter (Tashakkori & Teddlie, 2010; Tokumasu et al., 2022).

Data were collected through surveys (see Appendices D and E) to measure the effectiveness and impact of EdTech on preservice teachers' development. The data also provided deeper insights into preservice teachers' experiences, challenges and perceptions when using online applications and digital resources in their EGD module, as well as other modules during their first year of study.

The combination of these methods provided a holistic understanding of how EdTech resources can be integrated into an EGD module for first-year student teachers.

5.4 PRAGMATIC EDUCATION DESIGN

This research adopted a pragmatic educational design research (see Section 1.5.2) within the broader pragmatic paradigm, which aligned with the study focus and aim (see Sections 1.2 and 1.5). This research design was employed to explore the effective integration of EdTech in the EGD module for first-year student teachers. This iterative and contextual methodology allowed for an examination of real-world

education practices and facilitated the development of bespoke solutions that were aimed at enhancing learning outcomes (Ramanadhan et al., 2021). By synthesising principles of design-based research with a pragmatic orientation, the study aspired to bridge the theory–practice divide and yield insights derived from authentic classroom experiences (McKenney & Reeves, 2019).

Pragmatic education design research concentrates on the tangible effects of research interventions in educational settings, thereby providing a framework for evaluating how EdTech can be seamlessly incorporated into the EGD module (Newton, 2020). This approach addressed practical challenges through collaborative inquiry, in which the researcher and participants engaged in co-constructing knowledge (Newton, 2020). The iterative nature of this research design allowed for ongoing refinement based on participant feedback and evolving data, in alignment with contemporary best practices in education research (Reeves & McKenney, 2021).

This study was grounded in the pragmatic paradigm and prioritised practical outcomes and usability, which made it particularly suitable for investigating EdTech integration, especially in the context of the hybrid and HyFlex learning environments that emerged post-COVID-19 (Anderson & Shattuck, 2022). The pragmatic approach endorsed flexibility and adaptability and ensured that findings are both relevant and actionable for educators engaged in the EGD context (Anderson & Shattuck, 2022). It adopted a problem-solving orientation by targeting specific education challenges with context-sensitive methodologies (Morgan, 2020). Pragmatism facilitates a blending of qualitative and quantitative methodologies and aligns with the principles of methodological pluralism prevalent in contemporary education research (Mazlan, 2023). This epistemological stance highlights the significance of practical knowledge and its implications for educational practices, while advocating for the evaluation of knowledge based on its capacity to produce meaningful change (Dewey, as cited in Holtrop & Glasgow, 2020).

By utilising an inductive approach, the study collected qualitative insights from participants to unravel the complexities associated with integrating EdTech in the EGD module (Ramanadhan et al., 2021). A key characteristic of design-based research is its iterative cycle of design, implementation, evaluation and refinement, which ensures ongoing adaptation based on feedback (Reeves & McKenney, 2021). This cyclical

process ensures that solutions remain responsive to the needs of EGD students while effectively addressing the challenges inherent in hybrid and online teaching environments (Anderson & Shattuck, 2022).

Central to this research is the integration of EdTech in EGD teaching, which responds to the evolving demands of Education 4.0 and the expectations of digital natives (Newton, 2020). The research context encompassed first-year student teachers engaging with EGD content through a HyFlex model, which combines in-person and online learning experiences (Hassan, 2024). The pragmatic design approach facilitated an exploration of the specific challenges and opportunities presented by this hybrid learning environment (McKenney & Reeves, 2019).

By employing a pragmatic and inductive approach, the study gathered comprehensive classroom insights to investigate the role of EdTech tools in promoting student engagement and improving learning outcomes (Anderson & Shattuck, 2022). This emphasis on practical outcomes aligns with Mazlan's (2023) perspective that the primary aim of education is to catalyse meaningful change, rather than merely transferring knowledge.

In conclusion, the research methodology was characterised by its contextual, inductive and iterative nature, with the aim of developing practical, evidence-based solutions that are applicable in classroom settings (Newton, 2020). By focusing on real-world implications, the study offers valuable insights into the conditions necessary for effective utilisation of digital tools in first-year EGD teacher education (Ramanadhan et al., 2021). Furthermore, this approach addressed immediate challenges in the EGD context while contributing to broader conversations about the role of technology in Education 4.0 and the 4IR (Holtrop & Glasgow, 2020).

5.5 CASE STUDY RESEARCH STRATEGY AND METHOD

For this study in higher education (see also Section 1.5.3), a case study strategy was the most appropriate method. Based on Creswell's definition of case study (2014, p. 241), case could refer to first-year EGD student teachers who are defined by specific timeframes and activities (i.e., enrolled during 2024 for the first semester and participated in a 10-week intervention) (see also Sections 1.5.3.1 and 5.5.1). Additionally, case study was applied as data collection method that involves an in-

depth analysis of a specific subject or phenomenon (i.e., EdTech integration in a first-year EGD module) in its real-world context, with special reference to the higher education setting. The case study was conducted with student teachers enrolled in an EGD module (EGDC1614) at a South African university (see Section 5.6) during a 10-week intervention (see details in Section 5.5.1). Since this study focused on a single group, it is classified as a single-case study that was explorative in nature and that involves an in-depth investigation of a specific case. It explored the students' experiences with the use of EdTech in the learning and teaching of EGD in a HyFlex environment. Data were collected through two student questionnaires (see Appendices D and E), and the findings of this single-case study will be used to inform practice and enable the investigating of the fundamental attributes, significance and ramifications of the case (Hassan, 2024). Furthermore, because a case study method is also a type of data collection method that pursues in-depth understanding rather than breadth, additional techniques/sources were applied to gather data (see also Sections 1.5.3.3 and 5.7): two questionnaires for students (see Appendices D and E), one questionnaire for one EGD lecturer (see details in Appendix F), and a critical self-reflection (see Section G) on the 10-week intervention (see Appendix H and Section 5.3).

5.5.1 Overview of the intervention

The 10-week intervention (see Section 1.5.3.1 and Appendix G) followed a structured educational approach, by primarily focusing on integrating EdTech into an EGD module. The intervention evolved through multiple stages of digital engagement, and involved technology use from passive consumption to more advanced, autonomous applications (see Sections 2.4.3; Shaw et al., 2018). The TIM (Shaw et al., 2018) provided a structured framework for integrating technology into educational practices. The TIM guides educators to gradually increase the complexity and autonomy of technology use. It starts with basic, teacher-led activities (entry level), advances through guided and interactive use (adoption and adaptation) and culminates in autonomous, student-driven and innovative applications (infusion and transformation) (Shaw et al., 2018). At each level, technology and pedagogy are aligned to enhance learning outcomes. This systematic progression supports students to develop both technical and reflection skills through a blended learning model, by combining

traditional methods with EdTech to prepare students for complex, real-world challenges (Agbo et al., 2021). The intervention was structured as follows:

Week 1: The intervention started with an entry-level integration of technology. Students were introduced to the LMS, Blackboard, and its tools, while learning basic technological tasks such as scanning QR codes and uploading PDFs. The face-to-face sessions emphasised the need to understand module objectives and the key topics (see Table 5.2), as well as using applications for content consumption and simple tasks, such as creating short videos (see more details in Appendix G).

Weeks 2–4: At this level, that of adoption, students engaged in more constructive learning, where they followed the lecturer’s digital instructions but started applying digital tools for drawing exercises. PowerPoint was introduced as a drawing tool, supplemented by face-to-face tutorials, to guide students to develop foundational skills in digital and traditional drawing methods (see more details in Appendix G).

Weeks 5–6: The focus shifted to an adaptation level, where students started working more independently, but still under guided supervision of the EGD lecturer. They were encouraged to use digital tools, such as PowerPoint and OnShape, to apply geometric concepts to real-world tasks (see Table 5.2). Feedback loops were established through Blackboard, and independent work was monitored through digital submissions (see Table 5.2).

Weeks 7–9: The intervention moved towards infusion, with digital tools becoming seamlessly integrated into learning. Students regularly used various multimedia resources, including instructional videos created with platforms such as Renderforest and Doodle, to work on tasks. The focus expanded to more advanced drawing techniques, such as isometric and oblique drawings. This period marked a shift towards self-directed learning, though tutors remained available for support. A collaborative session via Blackboard Collaborate introduced more interactive elements, such as quizzes and assignments.

Week 10: In the transformation stage, students applied their skills in higher-order, innovative tasks through the practical assessment task (PAT). The PAT required a combination of traditional drawing methods and digital CAD skills and emphasised students’ autonomy to choose appropriate tools. The integration of feedback mechanisms through QR codes and forms supported a learning process through

reflection. The intervention concluded with a session focused on reflection and feedback. Students engaged in peer discussions and self-assessment, which provided insights into their learning experiences. The intervention, overall, encouraged digital fluency while supporting traditional skills, thereby fostering a blended learning environment.

Table 5.2 provides a summary of the 10-week intervention programme, by detailing its objectives, topics covered, activities and assessment tasks that were designed to enhance student engagement and mastery of key concepts. A complete schedule and programme of the 10-week intervention is given in Appendix H.

Table 5.2: Summary of 10-week intervention: Objectives, topics, activities and assessment tasks

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
1	Module exploration for skill acquisition: Enable students to gain an in-depth understanding of the module content and identify the key skills they will acquire throughout the course.	- Module orientation - Blackboard orientation - Teaching and learning style orientation	Groupwork: Divide into small groups. Each group reviews a section of the module overview. Key skills: Identify key skills the section covers and discuss real-world applications. Visual summary: Create a brief visual summary (mind map or poster) of your findings. Present and reflect: Present your summary to the class and reflect individually on which skills excite or challenge you.	Creating a short video of workspace. Upload to Blackboard Scan a written piece of work, making use of cell phone and convert to PDF - upload to Blackboard Download QR code scanner on phone
2	Mastering basic drawing principles and techniques: Develop foundational skills in graphical communication, freehand and technical drawing, and digital design using PowerPoint.	LU 1: Basic principles General drawing principles LU 2: Freehand sketches Freehand drawing Design How to draw digitally	Traditional drawing practice (F2F0) Tools and techniques: Students practise with drawing instruments (e.g., rulers, compasses, and set squares) to create: - Basic geometric shapes; and - Orthographic and isometric drawings of a simple object. Freehand sketching: Students sketch a simple object freehand, focusing on proportions, shading and clarity.	Homework Drawing 1 - Pencil Home drawing 2 - CAD (submit online - Blackboard)

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
			Digital drawing with PowerPoint tutorial: Provide a short tutorial on using PowerPoint for digital drawing, covering: • Basic tools (shapes, lines and connectors) • Alignments, grouping and layering for precision • Applying colours and effects to enhance visuals • Digital exercise: Students replicate one of their technical drawings (e.g., orthographic or isometric) digitally in PowerPoint	
3	Orthographic projection and geometrical constructions (traditional and digital techniques): Develop competency in orthographic projection, geometrical constructions and scales using both traditional drawing tools and digital methods.	LU 4: Orthographic projection Bolts and nuts + Castings and machine parts of simple objects from industry LU 3: Geometrical Constructions Division of line segments: equal parts, ratios etc. Construction of geometrical figures from given data-parallel lines, bisecting, triangles, polygons, rhombus, parallelogram, trapezium Scales and application: line scales, diagonal scales Enlarging and reducing, equivalent areas	Orthographic projection: Draw bolts, nuts, and simple machine parts in traditional and digital formats. Geometrical constructions: Divide line segments, construct geometric shapes (triangles, polygons, etc.), and use scales for enlarging, reducing, and equivalent areas, both manually and digitally. Design task: Create a simple mechanical part or industrial object applying learned techniques.	Homework Drawing 3 - Pencil Homework drawing 4 - CAD (Submit online – Blackboard)

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
		How to draw digitally	Presentation: Share traditional and digital work for peer and lecturer feedback. Reflection: Compare traditional vs. digital methods and highlight learning outcomes.	
4	Orthographic projection and geometrical constructions (traditional and digital techniques): Develop competency in orthographic projection, geometrical constructions and scales using both traditional drawing tools and digital methods.	LU 4: Orthographic projection Bolts and nuts and castings and machine parts of simple objects from industry LU 3: Geometrical constructions Division of line segments: equal parts, ratios, etc. Construction of geometrical figures from given data-parallel lines, bisecting, triangles, polygons, rhombus, parallelogram, trapezium Scales and application: line scales, diagonal scales Enlarging and reducing, equivalent areas How to draw digitally	Orthographic projection: Draw bolts, nuts and simple machine parts in traditional and digital formats. Geometrical constructions: Divide line segments, construct geometric shapes (triangles, polygons, etc.), and use scales for enlarging, reducing and equivalent areas, both manually and digitally. Design task: Create a simple mechanical part or industrial object applying learned techniques. Presentation: Share traditional and digital work for peer and lecturer feedback. Reflection: Compare traditional vs. digital methods and highlight learning outcomes.	Homework drawing 5 – Pencil Home drawing 6 – CAD (submit online – Blackboard)
5	Students demonstrate their ability to apply traditional and digital drawing techniques in compliance with *SANS Drawing Standards by:		Module test: LU 1–4	Module Test 1 Question 1 – Traditional -pencil method

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
	Traditional drawing: Producing a technical drawing on paper using pencil and traditional tools to showcase their understanding of manual drafting principles. Digital drawing: Creating a technical drawing using PowerPoint, demonstrating competency in digital design and application of SANS standards. Submission process: Successfully submitting their traditional drawing in hard copy at the test venue and their digital drawing via Blackboard, to illustrate their ability to manage dual submission methods effectively.			Question 2 – Digital drawing using PowerPoint (submit online via Blackboard)
6	Orthographic projection, assembly drawings, and practical assessment introduction: Develop proficiency in first angle orthographic projection and assembly drawings using traditional and digital methods (Onshape), while understanding the PAT requirements.	LU 4: First angle orthographic projection: Castings and machine parts of simple objects from industry LU 5: Assembly drawings: Castings and machine parts of general objects from industry How to draw digitally – Onshape	Orthographic projection: Create traditional and digital orthographic projections of simple machine parts. Assembly drawings: Develop assembly drawings of provided	Homework Drawing 7 – Pencil Home drawing 8 – CAD (submit online – Blackboard) PAT Start doing research

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
			components using traditional tools and Onshape. PAT discussion: Discuss the PAT objectives, tasks and evaluation criteria in detail. Reflection and submission: Reflect on learning outcomes and submit both traditional and digital drawings.	
7	Mastering assembly drawings with Onshape: Develop the ability to create assembly drawings of industrial objects using Onshape, including scanning and converting drawings to PDF, while working independently with multimedia resources.	LU 5: Assembly drawings: Castings and machine parts of general objects from industry How to draw digitally – Onshape	Introduction: Learn assembly drawing concepts and Onshape basics for creating exploded views and annotations. Practice: Create and export an assembly drawing in Onshape Draw an assembly drawing with a pencil and scan it in. Convert it to PDF. Submission: Submit completed PDFs via the LMS. Independent work week: Use videos, interactive notes, and websites about assembly drawings.	Home drawing 9 – Pencil Need to scan with phone and convert to PDF. Submit online (Blackboard) Continue with PAT
8	Creating pictorial views (oblique and isometric) with Onshape: Develop skills to create oblique and isometric pictorial views using traditional methods and Onshape,	LU 6: Pictorial views Oblique and Isometric How to draw digitally - Onshape	Guided Practice: - Sketch views traditionally. - Learn to create and export views digitally in Onshape.	Home drawing 10 – Pencil Need to scan with phone and convert to PDF. Submit online (Blackboard) Continue with PAT

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
	leveraging independent learning through multimedia resources.		Independent Work Week: - Use videos, interactive notes and websites to complete two pictorial drawings digitally. - Submit traditional sketches and Onshape PDFs.	
9	Develop skills to create one-point perspective drawings using both traditional and digital methods, while incorporating EdTech tools for learning, assignments, and quizzes.	LU 6: Pictorial views One-point perspective How to draw digitally – Onshape	Practice: - Create a traditional one-point perspective drawing. - Replicate the drawing digitally in Onshape and export it as a PDF. EdTech Integration: - Submit assignments via an LMS or platform. - Complete a quiz on Feedback Fruits to reinforce concepts. Reflection: Share and review drawings with peers and reflect on learning experiences.	Continue with PAT
10	Module test: Students demonstrate their ability to apply traditional and digital drawing techniques in compliance with SANS Drawing Standards by: 1. Traditional drawing: Producing a technical drawing on paper using pencil and traditional tools, showcasing their		Module test: LU 6	Formal: Module Test 1 Question 1 – Traditional pencil method Question 2 – Digital drawing using PowerPoint (submit online via Blackboard) Submitting PAT

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
	understanding of manual drafting principles. 2. Digital drawing: Creating a technical drawing using PowerPoint, demonstrating competency in digital design and application of SANS standards. 3. Submission process: Successfully submitting their traditional drawing in hard copy at the test venue and their digital drawing via Blackboard to illustrate their ability to manage dual submission methods effectively. PAT: Students demonstrate their mastery of EGD principles through original, individual work by: 1. Applying design procedures: Creating orthographic and pictorial drawings that reflect innovative solutions. 2. Demonstrating drawing precision: Producing accurate and neat freehand, manual, and CAD drawings. 3. Utilising CAD expertise: Showcasing professional proficiency in technical drawing using CAD tools. 4. Showcasing individual effort: Presenting original			

Week	Outcomes/Objectives	Topics	Activities	Assessment Task
	work that highlights their understanding and creativity in EGD.			

Note. LU = Learning Unit; * SANS = South African National Standards. It is a system of standards developed and maintained by the South African Bureau of Standards. These standards are used to ensure quality, safety, and consistency in products, services, and processes across various industries in South Africa.

The 10-week intervention seamlessly combined traditional and digital learning approaches to enhance students' competencies in EGD. Students utilised various traditional and digital drawing techniques to complete their assignments and were supported by diverse EdTech tools to access information on different topics. The class presentation modes included face-to-face sessions, HyFlex formats, fully online instruction and independent, self-directed work (see Table 5.2 and Appendix H.)

Through a progressive escalation of EdTech integration complexity, students transitioned from passive technology utilisation to more autonomous and innovative applications (see Table 5.2 and Appendix H). Initially, students engaged passively with EdTech tools, such as scanning QR codes and using Blackboard to access materials and submit assignments. As the programme advanced, they started to work independently by applying digital tools such as OnShape and PowerPoint to create technical drawings and collaborate through digital platforms. In Weeks 5–10, students autonomously selected and creatively utilised various digital resources, such as interactive e-notes and advanced drawing tools, thereby fostering a higher level of engagement and innovation (see Appendix H).

The intervention enhanced technical skills while simultaneously encouraging self-directed learning, teamwork and reflective practice through using EdTech to reflect on traditional drawing methods and the drawing using CAD-oriented methods (see Table 5.2 and Appendix H). Students developed technical expertise through tasks that required traditional and digital drawing techniques, such as creating orthographic and pictorial drawings using OnShape and PowerPoint. Self-directed learning was encouraged through independent assignments, e-notes and multimedia resources that encouraged students to explore concepts at their own pace. Teamwork was promoted via collaborative activities, such as group discussions and peer feedback sessions. Reflection practice was integrated through anonymous questionnaires and reflection activities that enabled students to assess their learning, identify areas for improvement and engage with feedback constructively (see Appendix H).

This organised, technology-integrated 10-week invention, based on the traditional curriculum, enabled students to interact more significantly with both digital and practical activities, which equipped them for solving future problems in the domain. Students enhanced their technical and digital skills through structured tasks, such as

creating orthographic and pictorial drawings using Onshape, PowerPoint and manual methods, while adhering to industry standards. The use of digital tools such as Blackboard for assignments, feedback and resource access provided a seamless integration of technology into the learning process. Independent work weeks, supported by e-notes and multimedia resources, equipped students further to tackle future challenges in the domain by fostering adaptability and proficiency in diverse tools (see Appendix H).

5.6 SAMPLING

As explained in Section 1.5.3.2, this study applied a total population sampling method because this type of sampling allowed for the inclusion of all relevant participants, thereby ensuring that the findings are representative and comprehensive (Cassim, 2024). This approach is especially effective when research involves specific, small groups that share unique characteristics, such as the first-year EGD students (N = 19) enrolled for the EGDC1614 module, and the related lecturer of the EGDC2714 module. Thus, total population sampling was the most appropriate type of purposive sampling for a small population; every member's input was critical to addressing the research questions (Adawiyah et al., 2021; Cassim, 2024).

The initial step entailed identifying the first-year students who were enrolled for the EGD module EGDC1614 in 2024. Students were invited to take part in the research on a voluntary basis (see Appendix A). Invitations were distributed via a variety of communication methods, such as classroom announcements, Blackboard announcements and an introductory video. The literature confirms that, by providing clear information, students could make well-informed choices regarding their involvement (Reason & Bradbury, 2019). The recruitment process was designed to ensure inclusivity and transparency and to ensure that all students were informed about the opportunity to participate in the study. Comprehensive information about the research – including its objectives, methodologies, potential benefits and risks – was provided to interested students. A brief invitation video outlining the project was uploaded to Blackboard for students to view. Those who expressed interest received a formal invitation letter detailing the project and the requirement to sign a consent form (refer to Appendix A).

Students who decided to participate were requested to sign a written consent form that explained their rights, the voluntary nature of their involvement and the confidentiality of the analysis and interpreting and reporting of their responses (see Sections 1.5.3.4, 5.8, 5.11 and Appendices B and C). It was important to emphasise this step to maintain the ethical standards of the research.

5.7 DATA COLLECTION METHODS

As stated in Section 1.5.3.3, in order to explore the integration of EdTech in the learning and teaching of EGD module EGDC1614, data were gathered through first-year EGD student teacher and lecturer questionnaires (see Appendices D, E and F). Creswell and Creswell (2023) confirm that it is advisable to include both open and closed-ended question to gather information from participants in a structured manner, which proved highly advantageous for education research, because it is possible to efficiently gather substantial data from a wide range of participants

5.8 DATA ANALYSIS

Data collection (see Section 1.5.3.4) via the two student questionnaires (see Appendices D and E) involved organising and distributing questionnaires through Google Forms. The quantitative data were analysed using Data Analysis & Report AI and Excel (see Section 1.5.2) while applying an inductive data analysis approach. I started by organising raw data in Excel, ensuring that it was clean, formatted and well-structured, with clear headers (Kishimoto et al., 2022). Excel's built-in tools, such as the pivot tables and statistical functions, and visualisation features enabled initial exploration and summary of data trends (Kang, 2023). Once the data were prepared, it were imported into Data Analysis & Report AI, which processed the datasets, generated automated insights, detected anomalies and provided predictive analytics (Kang, 2023; Kishimoto et al., 2022).

For the qualitative analysis, the Qualitative Thematic Analysis Assistant (Q-TAA) software/app was used, which is a digital or AI-powered tool that is designed to facilitate the process of thematic analysis in qualitative research (Kazimierczak, 2023). The thematic analysis involves identifying, analysing and interpreting patterns (themes) within qualitative data; data could be in the form of interview transcripts,

open-ended survey responses or observational notes (Kazimierczak, 2023). For the quantitative data I also employed thematic analysis of the qualitative data from both student and lecturer questionnaires (see Appendices D–F) to identify emerging patterns and insights. Braun and Clarke (2019) explain that this thematic analysis process involves systematically coding and analysing the information to identify key themes (see detail in Section 6.2 and Table 6.2) related to integrating EdTech in EGD education.

Additionally, as part of qualitative data collection, a lecturer questionnaire and self-reflection were applied (Appendices F and G). As part of the qualitative data analysis, I made use of the six levels of self-reflection proposed by McLeod (2024) (see Appendix G) in my praxis:

1. Description: Detailing the experience without making judgements;
2. Feelings: Describing thoughts and feelings experienced during the event;
3. Evaluation: Assessing what was good and bad about the experience;
4. Analysis: Understanding why things happened the way they did;
5. Conclusion: Summarising what could have been done differently; and
6. Action plan: Planning how to handle similar situations in the future.

The six levels were applied as a holistic framework to provide more depth, within which I reflected on the five levels of technology integration in educational settings of the TIM (Shaw et al., 2018) (e.g., in this study, on the EGD module). Using Gibbs's reflection model provided a detailed reflection that enriched the self-assessment and understanding of technology integration through the TIM framework.

Each of the five TIM levels (Shaw et al., 2018) was reflected on using the six steps of Gibbs, namely description, feelings, evaluation, analysis, conclusion and action plan. The Gibbs reflection cycle assisted me as an individual in transforming my experiences into practical lessons. It also helped me to develop ideas for future progress as I methodically addressed each of these stages.

5.9 QUALITY MEASURES

A comprehensive set of quality measures were adopted to ensure the rigour and reliability of this PhD research. These included **triangulation**, which involves using

multiple data sources or methods to validate findings (Jackson, 2021). It enhances the credibility and reliability of research outcomes by comparing and contrasting data from different perspectives (Lumapas, 2021). This study employed various data collection methods, including questionnaires administered to both students and the second lecturer, as well as the researcher's self-reflection. By integrating qualitative and quantitative approaches, the study enhanced the validity and reliability of its findings. To ensure cross-verification of the data, thematic analysis was conducted using the Qualitative Thematic Analysis Assistant software.

Trustworthiness ensured that the research process was both transparent and dependable. Trustworthiness is established through critical criteria, including credibility, dependability, confirmability and transferability, which collectively strengthen the integrity of qualitative research. Trustworthiness is crucial in qualitative research as it provides a framework for authors and helps editors and reviewers to evaluate the rigour of studies (Singh et al., 2021). In this study, trustworthiness was achieved by upholding ethical standards, such as obtaining informed consent, maintaining participant anonymity and protecting data privacy. The accuracy and objectivity of the findings were enhanced further through systematic coding, thematic grouping and software-assisted analysis. Additionally, thick descriptions offered detailed contextual accounts that contributed to the transparency and depth of the study.

Credibility is essential for ensuring the trustworthiness and reliability of research findings. It encompasses various aspects, including the integrity of the research process, the transparency of methodologies and the robustness of data collection and analysis. Singh et al. (2021) emphasise the importance of establishing credibility through rigorous qualitative research practices. Consensus on trustworthiness strategies is critical for enhancing the credibility of research outcomes. In this study, credibility was reinforced through multiple approaches – diverse instruments and participants, including students and lecturers – and triangulation. Participant feedback and reflections were incorporated to validate interpretations. Including a diverse participant profile, in this case, lecturers and first-year students, enriched the data pool. Methodological rigour was maintained by aligning data collection tools with the theoretical framework (TPACK); in this study, I ensured this through persistent observation by reading transcripts of study participants several times, coding,

recoding, looking for similarities and differences, distinguishing what was important from the irrelevant and by basing interpretation and reporting on what was most relevant for the study and across study participants. Preliminary findings were presented to an expert panel of lecturers who represented higher education institutions in South Africa, who confirmed that the interpretations accurately reflected their experiences.

Multiple rigorous review processes were undertaken to enhance the quality and credibility of this research on implementing EdTech in teaching and learning further. The research was initially presented at the Special Interest Group for Mathematics, Natural Science, and Technology Education and then reviewed by the Committee for Title Registration at the University of the Free State. Progress was shared during two brown bag seminars hosted by the Faculty of Education, where constructive feedback was received from colleagues and field experts. Additionally, self-reflections and preliminary findings were presented at two conferences attended by key stakeholders, which facilitated further critique and discussion. A vitalisation session with five national lecturers provided additional insights and recommendations, which were instrumental in refining the study and ensuring its rigour and relevance.

Dependability, which emphasises the consistency and repeatability of the research process, ensures that findings can be trusted and reproduced under similar conditions. It involves maintaining a clear audit trail and employing systematic data analysis methods, both of which contribute to the overall trustworthiness of research (Bingham, 2023). Detailed descriptions of the research design, methodology and intervention phases are provided to enhance repeatability. Regular self-reflection by the researcher improved methodological consistency further. One of the steps highlighted by Guba and Lincoln (1994) to achieve dependability includes triangulation, which is a cross-cutting element to also ensure credibility and, hence, dependability.

Confirmability ensures that the data shapes the results rather than the researcher's bias doing so (McSweeney, 2021). Thus, confirmability is a component of trustworthiness, which is widely referred to in quantitative research as objectivity or neutrality. In contrast to credibility, which depends on the efforts of the researcher, confirmability depends on participants by warranting the extent to which study findings are inspired by participants' perceptions rather than research interest and bias(es)

(Babbie & Mouton, 2001). This concept emphasises the importance of maintaining objectivity and transparency throughout the research process. It is important to implement strategies that mitigate the effects of confirmation bias, thereby enhancing the confirmability of the results. Regular reflexivity was an integral part of the research process and involved the researcher consistently examining and documenting potential biases and their influence on data interpretation. This reflection practice ensured a conscious awareness of how personal perspectives and positionality could shape the analysis and enable proactive measures to mitigate such impacts. The study strengthened its objectivity through triangulation, that is, utilising diverse data sources and applying thematic cross-checking with software tools such as Qualitative Thematic Analysis Assistant. These technologies facilitated systematic coding and pattern recognition and significantly reduced the risk of subjective interference. To uphold transparency, the results are presented with clear support from verbatim quotes and direct evidence from the data, thereby offering an authentic and credible representation of participant perspectives by cross-checking findings and the conclusions on which they are based, as well as reports made of the findings. This comprehensive approach reinforced the reliability and trustworthiness of the study and ensured robust and well-grounded findings.

Transferability assesses the extent to which findings can be applied in other contexts or settings to provide a robust framework for maintaining the quality and integrity of a study (Younas et al., 2023). Thick descriptions of the education environment, intervention context and participant demographics enable readers to assess the applicability of the findings to their own settings. This is confirmed by Guba and Lincoln (cited by Babbie & Mouton, 2001), who emphasise two strategies for ensuring transferability (which are equally important to ensure credibility and dependability): Thick description and purposeful sampling with maximum variation between participants.

5.10 LIMITATIONS OF THE STUDY

The study centred on a case study conducted at a university involving a small cohort of first-year students enrolled for the EGDC1614 module in the South African higher education landscape. One notable limitation was that a significant number of students had limited prior experience with the various applications (see Section 6.3.1.1),

resulting in initial frustration as they navigated the learning process. This initial phase of learning may have shaped the students' perceptions and attitudes toward the educational intervention.

Additional limitations include the restricted sample size, which may hinder the generalisability of the findings (Jacobsen et al., 2022). Furthermore, the concentration on specific modules at a single university has the potential to limit the applicability of the results to other educational settings (as highlighted in an expert panel – see Section 5.9). Future research incorporating a more diverse array of participants could help mitigate these limitations and yield a more comprehensive understanding of the subject matter.

5.11 ETHICS CONSIDERATIONS

Ethical practices are essential throughout the research process and reflect a commitment that extends beyond mere compliance with institutional guidelines (for comprehensive details, see Section 1.8 and Table 5.1). First and foremost, I adhered to the ethics clearance protocols established by the University of the Free State (see Appendix I). These guidelines include securing voluntary and informed consent, safeguarding participants from harm and respecting their right to privacy. The following guiding ethics principles applied to this study:

5.11.1 Written informed consent

In ethical research, written informed consent (see Appendix B) plays a prominent role (O'Connor et al., 2021). Informed consent involves presenting individuals with comprehensive information about the nature, risks and potential benefits of the proposed study, which empowers them to make informed decisions regarding their participation. Before the surveys and 10-week intervention case-study strategy commenced, the researcher explained the nature, risks and benefits of the research study to the participants. Ultimately, informed consent is critical to protecting individuals' rights, safety and well-being, and upholding ethical research principles. As participants in this study, students gave their verbal and electronic consent (see Appendix C) to participate in the online questionnaires (see Appendices D and E), as did the one lecturer who completed the lecturer questionnaire (see Appendix F) and,

ultimately, for the case study strategy for the 10-week intervention (see Appendices H), the participants had to provide written informed consent (see Appendices A and B). Only students of legal age and capacity participated in this research. The one lecturer who participated in the study also gave verbal consent before completing the questionnaire. Participants in this research were not forced to participate – involvement was entirely voluntary. Moreover, participants retained the right to withdraw from the study at any point without facing any consequences.

5.11.2 Confidentiality and anonymity

Confidentiality and anonymity are essential considerations when personal information is collected. Confidentiality refers to the protection of personal information, while anonymity refers to the protection of personal identity (Turcotte-Tremblay & Sween-Cadieux, 2018).

All data are presented in an unidentifiable form, by using pseudonyms or by referring to participants by number. Only the researcher has access to the data that is stored on a password-protected laptop and documents stored in a locked cabinet.

Confidentiality measures involved in this study are that personal information from the online questionnaires, self-reflection and the 10-week intervention case study strategy would be accessible to the researcher and the research supervisor of this study only. In turn, anonymity measures involved removing any identifying information from data so that individuals cannot be identified. Both confidentiality and anonymity are essential to ensuring that individuals are comfortable about sharing personal information and that their privacy would be respected and protected. Furthermore, measures were taken to uphold confidentiality and anonymity by using pseudonyms in reporting qualitative findings in line with the guidelines set by BERA (2024).

5.11.3 Vulnerable participants

Vulnerable participants are individuals who may be at increased risk of harm or exploitation when they participate in research studies. There was a risk of vulnerability because of the power relation between participants and the researcher, as the researcher was the lecturer of the module under investigation. Students might have felt compelled to participate in the case study and extra measures to ensure that

students felt protected and not obligated had to be taken by the researcher, such as regular reminders about voluntary participation, and reassurance that students could withdraw at any time without facing any consequences.

The benefit of this research outweighs the risks to the participants and the researcher undertook to conduct ethical and responsible research that contributes to the body of knowledge.

5.11.4 Power relationship

A power relationship existed between the researcher and some participants, especially concerning the case study. The researcher was the lecturer of this cohort. The power relationship between the lecturer and students, or the researcher and the participants, was an important dynamic to consider. This dynamic could be positive or negative: On the one hand, this power dynamic could facilitate and enhance the learning process by providing once-in-a-lifetime research opportunities that could be utilised to contribute to the body of knowledge. On the other hand, it could be negative, whereby students could experience manipulation and dysfunctional behaviour by the lecturer. Lecturers should tread carefully in this domain and be mindful of the impact of the power relationship on their student participants. A positionality statement is included in the study (see Section 5.12).

5.11.5 Beneficiation, reciprocity and remuneration

No participant benefited financially from this research.

5.11.6 Privacy, security and technology risks

The privacy of the data and research findings is protected through password encryption and secure storage in locked cabinets (see Section 1.8). In this day and age, where technology assists greatly in the collection and analysis of data, it is also essential to consider the implications of data storage on the Cloud, for instance. Accessibility to these data should be strictly limited and it is recommended to be encrypted, as these data should be stored for at least five years. Security issues such as data confidentiality, data integrity, data sovereignty and data privacy are essential to consider, and any related risk must be mitigated. As explained by Maree (2019), data confidentiality and integrity are the developer's responsibility, while data

sovereignty and privacy are the researcher's responsibility. The researcher should use strong passwords, do regular backups and ensure data safekeeping.

5.12 RESEARCHER'S REFLEXIVITY AND POSITIONALITY AND POWER RELATIONSHIPS

In this study, it was crucial to present a positionality statement, wherein the researcher articulates their position, biases, perspectives and background that may shape the research process and its outcomes. As the principal investigator of this research project that focused on pedagogical challenges faced by first-year EGD students in the EGD module (EGDC1614) at a South African university, I brought a wealth of experience to this inquiry. I had 25 years of teaching experience, including four years, specifically, in the first-year EGD module at a higher education institution.

I recognise that my professional background and personal biases may have influenced various aspects of the research, including the formulation of research questions, data interpretation and interactions with students and lecturers involved in the study (Schoenfeld, 2010). To address these potential influences, I committed myself to fostering transparency and reflexivity throughout the research process. This commitment included engaging in ongoing self-reflection to identify and mitigate biases, soliciting feedback from colleagues and research supervisors and employing rigorous research methodologies (Finlay, 2002). Additionally, I acknowledge the importance of bracketing my preconceptions to facilitate a more objective exploration of the research topic (Glesne, 2016).

This positionality statement serves as a transparent declaration of my standpoint and underscores my awareness of the potential influences on the research process. My aim was to conduct this study ethically, rigorously and sensitively by taking into account the complexities inherent in the research topic.

5.13 CONCLUSION

In this chapter, I outlined the methodological and research design (see Table 5.1) that was employed to investigate the integration of EdTech in the online learning and teaching of EGD for first-year student teachers. Utilising an interdisciplinary, exploratory case study strategy approach, my goal was to thoroughly analyse how a

TPACK perspective can facilitate effective EdTech implementation in a HyFlex environment. The pragmatic education design research methodology was intentionally selected to align with the study aims and research questions, and qualitative methods were used alongside complementary quantitative data collection techniques to deliver a comprehensive understanding of student engagement and learning outcomes. The detailed planning and execution of the 10-week intervention, supported by self-reflection practices, laid a strong foundation for analysing, interpreting and reporting the findings (see Chapter 6). The insights from this chapter set the stage for Chapter 6, where I will present and interpret the results and draw connections between the empirical findings and the broader context of EdTech integration in higher education.

CHAPTER 6

PRESENTATION, ANALYSIS AND REFLECTION

DISCUSSION OF EMPIRICAL FINDINGS

6.1 INTRODUCTION

This institutional single-case study (see Sections 1.5.3 and 5.5) reflects on the online learning and teaching experiences of first-year student teachers during integration of EdTech in a first-year EGD module through 10-week intervention (see Section 1.4), using TPACK as a theoretical lens (see Chapter 2) to meet the needs of Education 4.0 (see Chapter 4). Additionally, I also observed, commented and reflected on how diverse students' learning styles and instruction method preferences (see Chapter 3) influence online learning and teaching and the integration of EdTech (see Section 6.4). Data collection was conducted (see Section 1.5.3.3) by applying pre-intervention and post-intervention student questionnaires (see Appendices D and E). Additionally, a lecturer questionnaire (see Appendix F) was completed by a EGD colleague who taught EGD at second-year level, which shared insights and opinions about the integration of EdTech in a second-year module.

The analysis of these two questionnaires (see Appendices D and E) was based on the framework of TPACK. I identified and discussed 10 themes from these two questionnaires under each TPACK description area (see Section 6.3). In addition, the lecturer questionnaire (see Appendix F) was analysed, my personal self-reflection (see Section 6.3) was integrated and more detail, according to the reflection cycle (McLeod, 2024), is provided (see Section 6.4). The analysis of the questionnaire involved extracting valuable insights and identifying patterns from the gathered data. This enabled me, as the researcher, to analyse and infer considerations to make informed decisions based on these results. As a participant researcher, I reflected on and integrated my personal teaching and learning experiences and self-reflection viewpoints (see Sections 6.3 and 6.4). Thereafter, the panel of experts' viewpoints are given for validation purposes, and the review of data triangulation is presented (see Sections 6.5 and 6.6).

The reporting and discussion of this doctoral study starts with the profile and demographics of the first-year EGD students (see Section 6.2), after which I delved into the data gathered from the two student questionnaires (see Section 6.3), the lecturer's questionnaire (see Appendix F), the self-reflection (see Sections 6.3 and 6.4) and the feedback of the panel of experts (see Section 6.5). I reviewed the data triangulation (see Section 6.6) and the conclusions reported in Section 6.3 will be outlined in Chapter 7.

6.2 PARTICIPANT PROFILE AND DEMOGRAPHICS

As explained in Section 5.5, the student profile of this study is identified as first-year BEd FET students enrolled for the EGDC1614 module for the academic year 2024. These students completed the first pre-intervention questionnaire (see Appendix D) at the start of the semester and, thereafter, all 19 first-year students in the EGDC1614 module attended the 10-week intervention (see Appendix E). Thereafter, the second post-intervention, questionnaire (see Appendix E) was completed. However, the second questionnaire was only completed by 15 students, because two of the students were not available due to medical reasons, and two students did not respond.

A questionnaire was also sent to the lecturer responsible for teaching EGD in the second year, as explained in Section 5.5. A self-reflection (see Appendix G, Sections 6.3 and 6.4) was also completed by the researcher.

6.2.1 Demographic age and gender

6.2.1.1 *Ages of first-year EGD students*

Although people's ages (see Appendix D. Part 1) are not directly related to the integration of EdTech, I regarded it important to include it in the analysis because it could have an influence on the attitudes of first-year EGD students. The assumption is that younger students would be more positive about and engaged with EdTech, while their older counterparts would be more resistant to implementing EdTech innovations. The first-year EGD student participant profile of this study reveals that the majority of participants were first-time pursuers of higher education (see Figure 6.1).

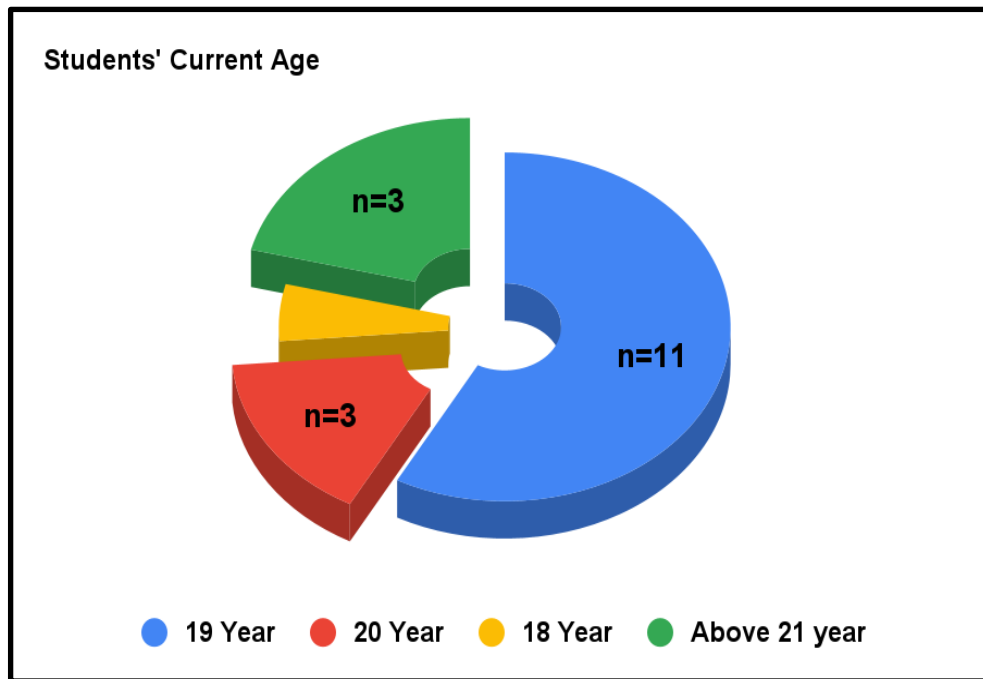


Figure 6.1: Sector diagram indicating ages of EGD first-year students

In total 11 of the first-year EGD student teacher participants were aged 19 years, which suggests that this group was largely composed of recent high school graduates or individuals in the early stages of their academic careers. Only three participants were aged 20 years and another three were aged 21 years. The category Above 21 years refers to a smaller, potentially non-traditional student population, but further data would be needed to confirm this, which was beyond the scope of the study. This observation could possibly align with the changing demographics of students towards more diversity in higher education (see Section 3.2).

6.2.1.2 Genders of first-year EGD students

Although the gender category is not directly related to the integration of EdTech, I deemed it as significant to include in the analysis because it could have an influence on the attitudes of first-year EGD students when integrating EdTech. As illustrated in Figure 6.2, the gender distribution of first-year student enrolment in the given faculty of the university, and in the EGDC1614 module confirms significant disparities in male and female representation for these three categories.

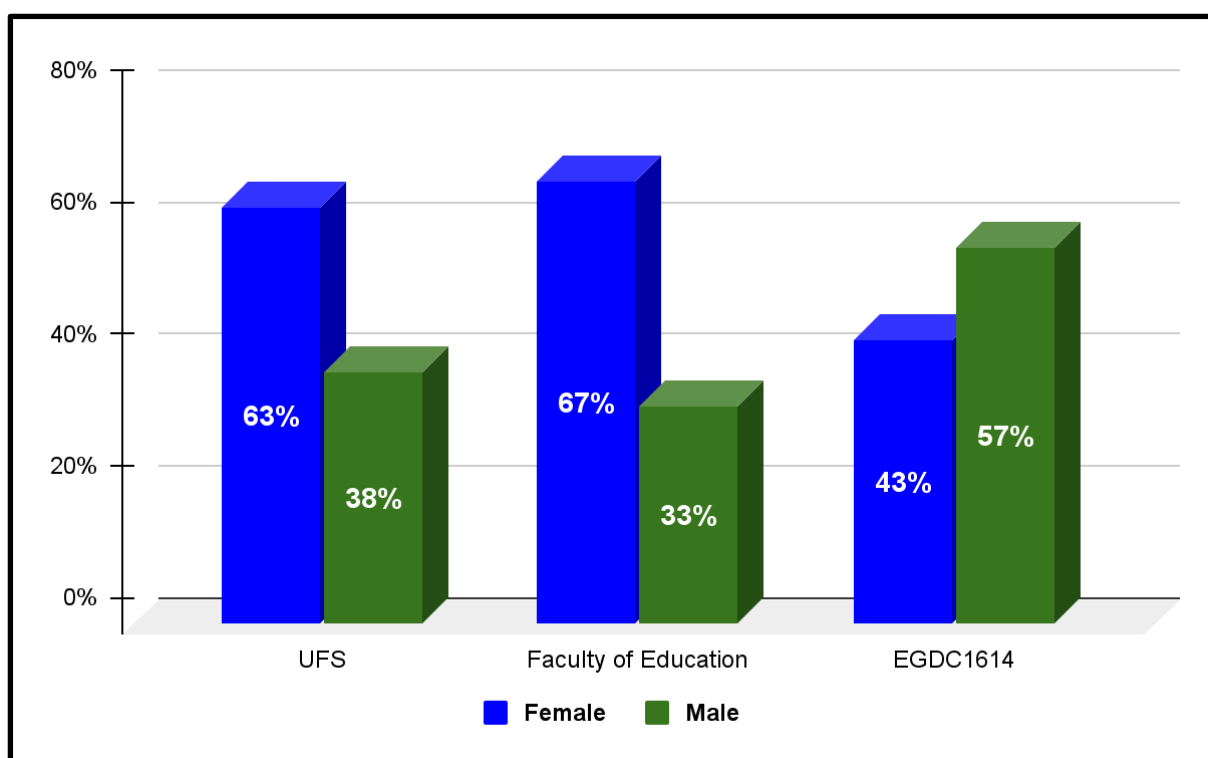


Figure 6.2: Bar diagram indicating gender distribution of first-year student enrolment at the University of the Free State, the Faculty of Education and the EGDC1614 module

In Figure 6.2, a comparison of the gender of the students enrolled at the University of the Free State, the university's Faculty of Education and the EGDC1614 module is presented. The majority (63%) of the total university student population and 67% of the students in the specific Faculty of Education were female. This trend aligns with a broader pattern observed in higher education, of enrolment rates by women surpassing that of men.

However, the EGDC1614 module, which is a module in a STEM (science, technology, engineering and mathematics) discipline programme, appears to be dominated by male students ($n = 57\%$) in the BEd programme. This trend in the module could be related to STEM disciplines, where male students tend to outnumber female students because of factors such as societal expectations, interests or educational pathways that prioritise technical subjects for men (Idahosa & Mkhize, 2021).

6.2.1.3 *Ages, genders and years of teaching experience of lecturers*

The age category of the researcher and the lecturer responsible for teaching the second year EGD is 45–54 years. Both of these two male EGD lecturers had more than 20 years of teaching experience.

6.2.2 Demographic overview of residence of first-year EGD student teachers

The first-year EGD student teachers had to indicate where they lived, which was vital to determine their home contexts and learning spaces. Where students live has an influence on their EdTech needs and the researcher had to determine the different levels of competence and availability of and access to EdTech.

In total 13 of the first-year EGD student teachers indicated that they lived off campus, while six student teachers lived on campus. Various factors, including housing availability, cost and personal preferences, may explain differences between students living off and on campus. In Section 3.2, I explained the international trends regarding student demographics in higher education as they relate to the diverse backgrounds of students in terms of academic preparation, socioeconomic status and personal responsibilities. The decision to live off campus may also be influenced by age, economic background and the need for flexibility in balancing work, family and study commitments. These multiple roles align with the literature (see Section 3.2), which highlights the need for education institutions to cater for Generation Z's multimodal learning preferences by, for example, integrating diverse and interactive teaching methods to engage students, regardless of their location.

6.2.3 EdTech usage per week and device ownership of first-year EGD student teachers

The focus of this study (see Section 1.4) is on the integration of EdTech in a first-year EG module, thus the first-year EGD participants were asked to indicate their weekly EdTech usage and device ownership. Data for this section were extracted from the pre-intervention questionnaire (see Appendix D, Question 2.1) and the post-intervention questionnaire (see Appendix E, Questions 2.1 and 2.2).

In Table 6.1 (see also detail of discussion in Section 6.2.4) the reports of first-year EGD students regarding the primary time allocation for weekly EdTech use, as well the place where EdTech was used, are indicated.

Table 6.1: EdTech usage of first-year EGD student teachers per week

Time allocation for using EdTech	Place of use at residence	Where EdTech was used*
8 students spent between 6 and 10 hours per week using EdTech	Residing off campus (n = 13)	8 first-year EGD student teachers were mostly on campus when they used EdTech
	Residing on campus (n = 6)	7 first-year EGD student teachers were mostly off campus when they used EdTech

Note. * Data missing for 4 participants.

As indicated in Table 6.1, it appears that 8 first-year EGD student teachers spent approximately 8 hours per week using EdTech (the median, which is the midpoint of the dataset, is 8 hours). As explained in Section 6.2.2, most first-year EGD student teachers live off campus (i.e., commuter students), while 6 first-year students live on campus in hostels. Although the majority of the first-year EGD student teachers lived off campus, 8 participants indicated their preference for using EdTech is on campus, while 7 participants preferred using EdTech off campus. The reason for the difference between where EdTech was used by the first-year EGD student teachers could possibly be the availability of or their access to EdTech, or infrastructure issues, such as electricity or Wi-Fi.

Additionally, for this research on EdTech interaction, it was essential to establish the number of devices owned by first-year EGD student teachers, as well as the purposes they used these devices for. Data for this section were obtained from the pre-intervention questionnaire (see Appendix D, Questions 3.1, 3.2 and 3.3) and the post-intervention questionnaire (see Appendix E, Questions 2.1 and 2.2). Device ownership and usage purposes of first-year EGD student teachers are illustrated in Table 6.2.

Table 6.2: Device ownership and usage purposes of first-year EGD student teachers

How many devices owned	Type of devices owned	Purpose of use (academic, other do not use)	Usage location (on campus, off campus)
Most respondents (10 out of 15) owned two devices, making this the most common ownership pattern	All the first-year EGD students owned cell phones	Devices were essential for work and personal use and offered flexibility and ease. The data show 7 first-year EGD student teachers used cell phones for academic purposes and 5 used them for non-academic activities, such as entertainment or communication.	7 Participants used their cell phones on campus, and 4 predominantly used their cell phones off campus
Few participants owned one device (3 participants) or three devices (2 participants)	Ownership of laptops shows an increase from only 10 students owning laptops pre-intervention, to 13 owning laptops post-intervention	Laptops are mainly used for academic work, with 11 people using them for this purpose and only 2 using them for non-academic purposes.	6 Participants used their laptops on campus and 6 used them off campus
	Desktop computers were mentioned by only 2 students	Two people used desktops for academic purposes, while one used it for non-academic activities such as entertainment or personal work.	2 Participants reported using desktop computers on campus
	No students owned tablets pre-intervention, and 2 owned tablets post-intervention	Only one person used a tablet for academic purposes. One person used a tablet for non-academic purposes.	No one used a tablet on campus, and 2 used them off campus, likely for leisure activities such as reading or watching videos

In Table 6.2 (also see detail of discussion in Section 6.2.4), the focus is on the number of devices owned by the participant students and the purposes for which they used the devices. The analysis of students' EdTech usage and device ownership (see Table 6.2) highlights the significance of campus facilities for supporting their academic engagement. Many first-year EGD student teacher participants ($n = 14$) preferred using educational technology on campus, which suggests they benefited from

computer labs and reliable internet resources. This supposition is confirmed by comments by first-year EGD student teachers:

I used the UFS Computer Lab to access online platforms. (P1)

I used to work a lot on campus from 8:00 in the morning till 15:00 in the evening, and in that time I used to study and do my work. (P9)

Most of the time I'm on campus to use different types of technology since the University has a lot of resources for us as students. (P12)

I came to campus on the weekends to make notes regarding the module. (P13)

These comments demonstrate how on-campus technology facilitates productive study routines and seamless access to the necessary tools, which are vital for EdTech integration, especially in EGD learning and teaching.

In contrast, students who resided off campus faced other challenges and often relied on home-based technology. The following responses confirmed this challenge:

I live far from campus, so I am unable to come every time I have a class (P2).

I find it much easier to work in the comfort of my own room, and at times, it's easier to connect to the Wi-Fi there (P4).

I usually study, summarise the content and work on my laptop when I get home. Because most of the time I was off campus, and I didn't have physical class(P5).

I spend more time studying when I am at my accommodation as compared to when I'm on campus (P6).

The responses above show that these students prefer studying from home, where they can manage their own environment and have access to reliable Wi-Fi. Both on-campus and off-campus needs must be considered when designing the integration of EdTech in EGD modules.

Additionally, the analysis of device ownership underscores the technology habits of Generation Z. Most students owned mobile devices such as laptops (n = 16) and cell phones (n = 19), which they used extensively for academic tasks. However, desktops and tablets were less popular, reflecting this generation's preference for portable, multitasking-friendly technology (see Appendix D, Question 3.2 and Appendix E,

Question 2.2). These trends are supported by the literature (see Section 3.5) and highlight the importance of mobile-friendly education strategies.

This study underscores the necessity for higher educational institutions to recognise and cater for the technology habits of contemporary students and the presence of online attributes. For example, on-campus resources, such as computer labs and reliable Wi-Fi, are critical for facilitating educational technology use. For off-campus students, access to stable, personal technology and effective time and workload management from home were essential. Therefore, developing education strategies that support both on-campus and remote learning environments is crucial for accommodating the diverse needs of students today. Institutions must strive to create mobile-friendly EdTech systems and be responsive to the different learning environments in which students find themselves, as confirmed by the literature (see Chapters 3–4) and demonstrated by this study (see Chapters 6–7).

6.3 REFLECTING ON STUDENT EXPERIENCES WITH EDUCATIONAL TECHNOLOGY IN ENGINEERING GRAPHICS AND DESIGN

The responses of first-year EGD students to both the pre-intervention questionnaire (see Appendix D) and the post-intervention questionnaire (see Appendix E) were analysed and presented for discussion. The three main TPACK description areas (i.e., TK, PK, and CK) served as the foundation for these self-constructed instruments (see Appendices D–E). I identified themes from responses to both questionnaires (see Table 6.2 for more detail). After each theme related to the TPACK description areas, the lecturer's reflections were integrated (see Sections 6.3.1.6, 6.3.2.4 and 6.3.3.3, discussed in detail in Section 6.4).

Table 6.3: TPACK description areas and related themes obtained from thematic analysis

TPACK description areas	Themes	Description
6.3.1 Aspects related to TK domain	6.3.1.1 Perceptions and experiences of EdTech resources	Perceptions and experiences of using EdTech resources before and during the intervention in the module. Appendix D: Questions 3.4, 3.10 Appendix E: Question 2.5
	6.3.1.2 Usage and frequency of EdTech tools	How often and in what capacity are the EdTech tools being used in the module (both initially and after intervention). Appendix D: Questions 3.6, 3.7, 3.11 Appendix E: Questions 2.3, 2.6, 2.10
	6.3.1.3 Challenges and impediments in using EdTech	Difficulties and limitations faced by EGD students when engaging with EdTech tools (both initially and after intervention). Appendix D: Questions 3.12, 3.15 Appendix E: Questions 2.4, 2.9
	6.3.1.4 Growth in TK	Identify the growth or improvement in technological knowledge over time, particularly in the context of the course. Appendix D: Questions 3.13, 3.14 Appendix E: Questions 2.7, 2.8
	6.3.1.5 Confidence and satisfaction with EdTech tools	This category evaluates students' confidence and satisfaction with the EdTech tools, to determine whether their confidence increased and whether the tools met their needs. Appendix D: Questions 3.5, 3.8, 3.9 Appendix E: Question 2.11

TPACK description areas	Themes	Description
6.3.1.6 Lecturer reflections: This section provides insights from both the researcher and a lecturer colleague involved in teaching EGD.		
6.3.2 Aspects related to PK	6.3.2.1 Learning environment	This category explored the types of learning environments that students prefer and how these environments influence their ability to engage and succeed in their courses. Appendix D: Questions 4.1, 4.2, 4.3 Appendix E: Questions 3.1, 3.2
	6.3.2.2 Digital tools and resources	This category focused on the impact of digital tools on students' understanding of course content and how effectively these tools are used in teaching. Appendix 4: Questions 4.4, 4.6, 4.7, 4.8 Appendix E: Questions 3.3, 3.5
	6.3.2.3 Pedagogical strategies	This section examined the teaching methods that incorporate technology, by highlighting which approaches students find most helpful for their learning, and provides suggestions for improvement. Appendix D: Question 4.5 Appendix E: Questions 3.4, 3.6, 3.7
6.3.2.4 Lecturer reflection: This section provides insights from both the researcher and a fellow lecturer involved in teaching EGD.		
6.3.3 Aspects related to CK	6.3.3.1 The use of EdTech resources in the module EGDC1614	This category assessed if students found EdTech tools helpful, with the baseline covering general EdTech resources and the reflection file focusing on course-specific EdTech. Appendix D: Questions 5.1, 5.2, 5.3, 5.4 Appendix E: Question 4.2
	6.3.3.2 Effectiveness of EdTech resources	This measured how well EdTech tools supported learning, with reflection data being slightly more critical. (Appendix D: Questions 5.5, 5.6) (Appendix E: Question 4.1)

TPACK description areas	Themes	Description
6.3.3.3 Lecturer reflection: This section provides insights from both the researcher and a fellow lecturer involved in teaching EGD.		

6.3.1 Technological knowledge

Aspects related to the first TPACK description area of **TK** focuses on the views of first-year EGD students of EdTech resources before (see Appendix D, Section 3) and during (see Appendix E, Section 4) the EGD module (EGCD1614) intervention. The following five themes were identified: Perceptions and experiences of EdTech resources (see Section 6.3.1.1), Usage and frequency of EdTech tools (see Section 6.3.1.2), Challenges in using EdTech (see Section 6.3.1.3), Growth in TK (see Section 6.3.1.4) and Confidence and satisfaction with EdTech tools (see Section 6.1.3.5). These themes provide insights into how first-year EGD students engage with, overcome obstacles facing (see Section 6.3.1.3) and develop skills through EdTech, to shape their overall learning experience.

Figure 6.3 gives a holistic overview of the five themes that were identified in the related TK description area and which of the five subsidiary research questions (see Sections 1.4 and 7.2) were answered by each theme.

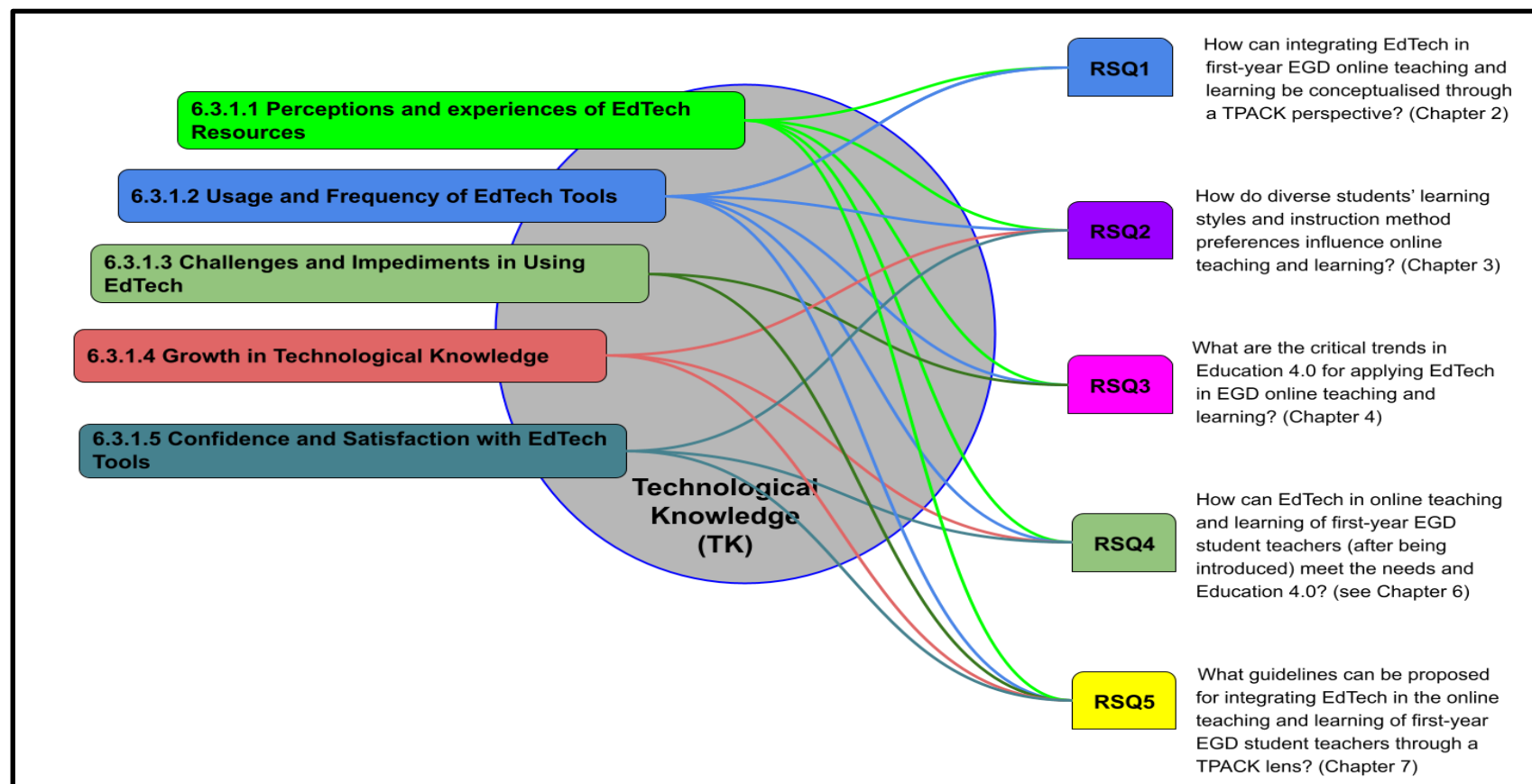


Figure 6.3: TPACK description areas and themes obtained from thematic analysis addressing the subsidiary research questions

6.3.1.1 Perceptions and experiences of EdTech resources

During the 10-week intervention, the first-year EGD students had no restrictions on the type of devices applied in the EGDC1614 module. However, the ETech resources were introduced according to TIM (see Appendix G) during lessons.

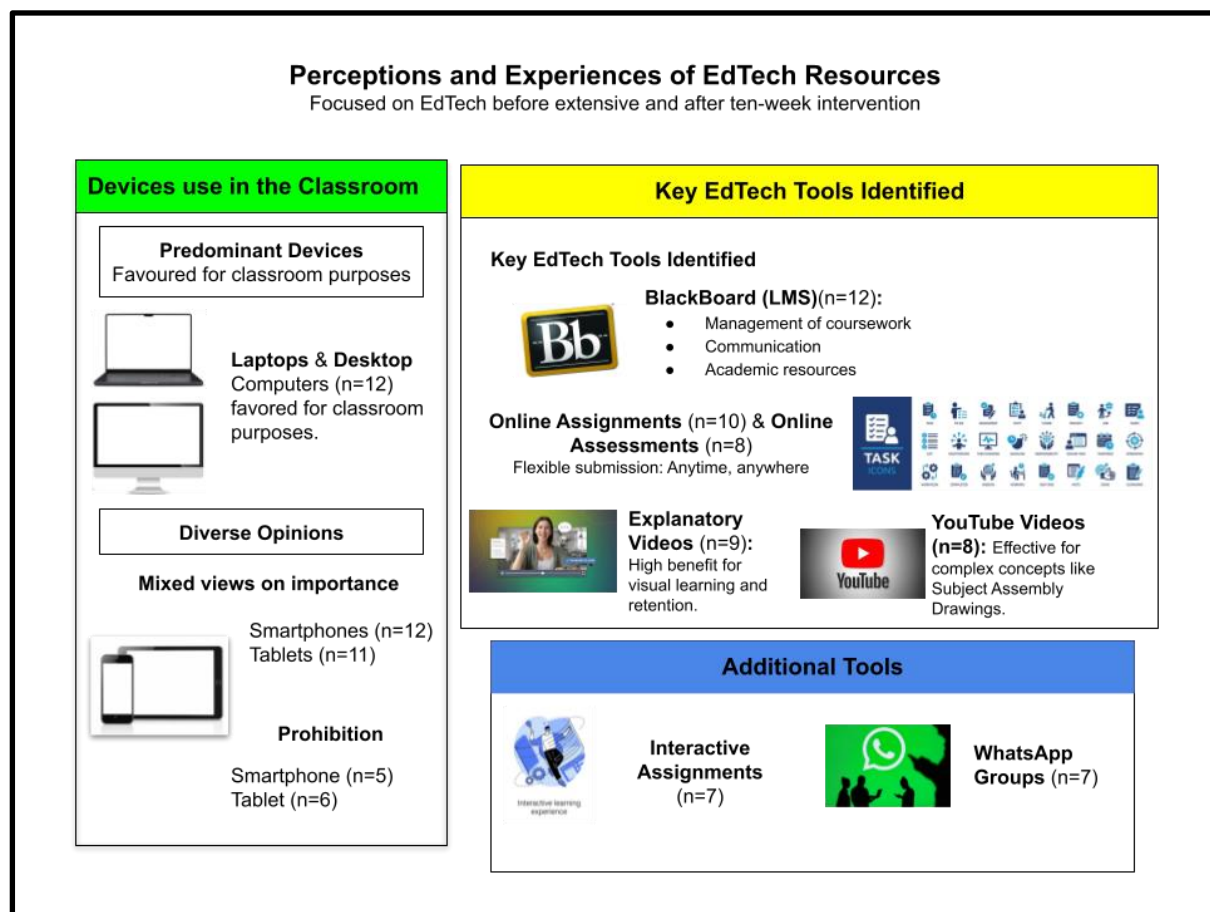


Figure 6.4: Perceptions and experiences of EdTech resources

First-year EGD students' perceptions and experiences of using EdTech resources (with special reference to devices and tools) before extensive exposure or formal training (see Section 5.4) were explored. The responses of the participants fluctuated between the positive and negative sides of the continuum. Findings indicate that all devices were regarded as important (smartphones, tablets/iPads, laptops and desktop computers), but for classroom purposes, most participants (n = 12) indicated **laptops and desktop computers** as the devices they used predominantly. This links with other research on the digital fluency of Generation Z, which highlights their dependence on technology for education purposes and social engagement (see

Chapter 3). Diverse opinions existed among first-year EGD students regarding the importance of smartphones (n = 12) and tablets (n = 11) in classrooms. A minor number of first-year EGD students referred to the prohibition of smartphone (n = 5) and tablets (n = 6) use during lessons, though no reasons were given, and the matter was regarded as beyond the scope of the instrument in Appendix D).

After the 10 weeks of intervention (see Appendix G), the first-year EGD student teachers indicated that the following EdTech resources (i.e., tools) were used during the 10-week intervention: **Blackboard** (LMS) (n = 12), **online assignments** (drawings) (n = 10), **online assessments** (module tests) (n = 8), and **CAD drawing** tools (n = 8) were highlighted as very important EdTech tools. It appears that most of the first-year EGD student participants (n = 12) identified Blackboard (the LMS in use at the university) as crucial for the management of coursework (P5, P8, P13, P14), communication (P1, P2, P4, P6), and accessing academic resources (P3, P7, P9, P15).

Blackboard helps me stay up to date and not miss any important deadlines.
(P5)

Blackboard helps me keep track of all my work. (P8)

I rated Blackboard, explanatory videos, and assessments as my most beneficial way EdTech tools because I always use them for my academics, and they always deliver top-notch assistance. (P13)

Because it is very important for my academic skills and learning experience.
(P14)

Communication is much easier than having to go face to face for the announcements, and I can do the assignments in my comfort no matter the time, especially in my room. (P1)

Because without blackboard we wouldn't be able to communicate with the lecture and receive announcements. (P2)

Blackboard is where the lectures communicate well with us and provide content for that module or topic. (P4)

Blackboard is the most important because everything we do is communicated on Blackboard. (P6)

These positive experiences of the first-year student EGD teachers confirms the essential function of Blackboard in promoting organised, interactive learning environments. This finding aligns with the literature regarding the significance of structured, technology-enabled environments for meeting diverse student needs (see Section 3.5).

Additionally, online assignments and online assessment gave students the opportunity to submit their work at any time and from any place. It made it possible for students to improve planning their work according to their schedules. This finding corresponds closely with the literature (see Section 3.2.3), which reports that diverse, modern students like flexibility regarding when and where they access their work and also when and where they study. The key attributes of online learning environments (see Section 3.2.3), such as explanatory videos ($n = 9$), is generally considered highly beneficial, particularly for visual and explanatory learning, which helps students improve understanding and retain academic content material. YouTube videos ($n = 8$) were also recognised as valuable resources, likely because of vast library of educational vast library of educational content, for enhancing learning and clarifying complex content. For example, it appears that subjects such as assembly drawing greatly benefited from visual aids on YouTube, which facilitated understanding of complex concepts. The easily accessible content of YouTube proved to be an invaluable resource for students, which enhanced comprehension and clarified challenging subjects. Both of these EdTech tools served as effective means for improving drawing skills, by offering practical, step-by-step demonstrations. However, participants expressed a general view that the effectiveness of these tools may vary, based on the specific subject topic or individual learning preference. It also can be deduced from the responses of the first-year EGD student teachers that interactive assignments ($n = 7$) and WhatsApp groups ($n = 7$) were important; however, their influence may vary depending on how actively they are used and the nature of the design and execution of the activities. Furthermore, websites ($n = 3$) and e-notes ($n = 3$) received lower ratings from participants, which suggested a potential need for enhancement or a reduced significance in their current format. Although these tools correspond with the multimedia learning preferences of modern students with diverse needs, their diminished perceived value suggests a necessity for enhancements or the development of more engaging alternatives. These findings underscore the

significance of offering dynamic, interactive tools that deliver real-time feedback that is aligned closely with the expectations and learning preferences of contemporary students.

6.3.1.2 Usage and frequency of use of EdTech tools of first-year EGD student teachers

This theme examines the usage patterns of EdTech resources by focusing on the frequency of and manner in which students engage with these tools, both in the initial stages of use and after extended interaction, over time.

PowerPoint (n = 7) and YouTube (n = 3) were commonly referenced as resources utilised prior to the commencement of the 10-week intervention, which highlights a significant dependence on these tools for educational purposes. This trend aligns with contemporary students' preferences for visual and multimedia learning, as discussed in Section 3.4). The acknowledgement of YouTube as a valuable supplementary resource reinforces the findings presented in Section 3.5, which underscore the appeal of digital platforms that offer accessible and engaging content.

After the 10-week intervention, students were surveyed regarding their usage of specific EdTech resources, not only for the EGDC1614 module but across their entire curriculum. The results reveal considerable variations in usage levels for the different tools. The LMS was utilised extensively across the curriculum (n = 7), which underscores its critical importance in the education landscape (see Section 4.2.1). Moreover, online collaboration tools were recognised as significant, with 6 participants employing them across all courses; however, while all participants indicated they used or had started using these tools in the EDGC1614 module, it appears that students did not consider them a constant or essential part of their collaborative efforts. This finding indicates a continued reliance on face-to-face collaboration.

The use of e-books was noted at a moderate level (n = 4), suggesting their growing applicability as a viable alternative to traditional textbooks. Conversely, e-portfolios (n = 14) and simulations and educational games (n = 12) exhibited no engagement from students, indicating a marked deficiency in their incorporation in the curriculum. This limited integration reflects their gradual adoption in educational settings (see Sections 4.2.1 and 4.2.5).

The role of social media as an educational tool elicited mixed responses, with six students indicating they did not utilise it, while others acknowledged its potential, which reflects diverse perceptions among participants. Furthermore, all 15 participants reported no use of 3D printers or non-traditional interfaces, which highlights ongoing challenges regarding accessing and integrating these technologies in higher education. Despite the prevalence of reliance on digital tools by contemporary students, a noteworthy number of students ($n = 3$) expressed a preference for traditional teaching and learning methods, which underscores the persistent issue of the digital divide, as discussed in Section 4.2.5.

The frequent use of specialised software for CAD drawings has become crucial for completing technical tasks, particularly the conversion of 2D designs into complex 3D models. The data indicate that academic purposes are increasingly becoming the primary application of laptops. These purposes encompass attending online lessons, completing assignments, utilising drawing software, accessing Blackboard, communicating via email, watching educational videos and conducting research, with activities occurring both on and off campus.

Smartphones ($n = 10$) have emerged as vital tools in facilitating classroom activities, including online lessons, accessing Blackboard, managing email communications, checking notifications and taking notes (such as using Google Notes). Their use was primarily on campus for activities such as taking surveys and off campus for remote learning and communication. This finding aligns with the research presented in Chapter 4 concerning the significance of mobile tools in the context of Education 4.0, which emphasises the need for flexibility in learning environments.

Overall, the findings highlight the importance of interactive and structured tools for enhancing student engagement and learning outcomes, as discussed in Chapters 3 and 4. While digital resources play a crucial role for contemporary students, there exists an opportunity to augment or complement less used interactive tools, to enable students to fully leverage the advantages offered by these technologies.

6.3.1.3 *Challenges and impediments to first-year EGD student teachers using EdTech*

This theme addresses the barriers, limitations and challenges that students encountered when they utilised EdTech tools. It explores both the initial obstacles and

the persistent issues that arose as students progressed through the course. Additionally, it emphasises the positive perceptions that emerged throughout this experience.

A significant barrier identified by the study was the presence of subject-specific challenges (P2, P3, P5, P6, P11, P14, P15). Participants reported feeling intimidated by various EdTech tools and expressed uncertainty regarding their effective use. One participant articulated: *I find EdTech resources quite scary to interact with as I do not know what I am doing most of the time* (P1). This view underscores the necessity for adequate guidance and ongoing support when implementing new technologies for student use. In the absence of such support, students may feel overwhelmed or discouraged, which could hinder their engagement with digital tools that are crucial for enhancing their learning experiences.

Moreover, participants highlighted that EGD is an inherently practical subject, which is reliant on hands-on activities that are challenging to replicate in an online format. Consequently, online lessons for certain topics posed difficulties, as students expressed a preference for in-person interactions with instructors. This observation sheds light on a critical limitation of EdTech: the effectiveness of digital resources can be significantly influenced by the nature of the subject matter. Practical and interactive disciplines necessitate greater physical engagement, thereby complicating the transition to online learning in the absence of specialised resources (see Section 4.2.5).

Technical issues emerged as another primary obstacle for students. Participants, particularly P1, P9, and P10, expressed frustration related to network connectivity problems. Slow or unstable Wi-Fi hindered their ability to complete and submit assignments, even while on campus. Students navigated these challenges by utilising mobile hotspots and private data plans, coupled with diligent planning and preparation. Additionally, concerns regarding outdated hardware (P7, P12, P13) were noted, as laptops and desktop computers in campus laboratories were often unable to support the software required for specific tasks. Students lacking dependable equipment or internet access encountered difficulties in digital collaboration, which exacerbated the digital divide further (see Section 4.5.2). Technical difficulties, which included unreliable Wi-Fi and antiquated devices, were recurrently identified as significant

barriers that impeded students' ability to submit assignments and access resources punctually (see Section 4.3.2). This finding underscores an imminent equity issue, as students from less privileged backgrounds may face disadvantages in courses that predominantly rely on EdTech. The digital divide remains a substantial obstacle to equitable participation in education, particularly when digital resources are integrated in the curriculum.

Device ownership was cited as a limitation by 13 participants, who emphasised the necessity of laptops for academic success. Without access to laptops, students struggled to submit assignments on time and missed critical notifications. Laptops were deemed essential for retrieving information, utilising specific software, taking comprehensive notes and engaging with interactive content. While most participants acknowledged the benefits of EdTech, one student remarked that they balanced its usage with traditional textbooks and indicated no discernible influence on academic success.

In terms of familiarity and the learning curve associated with new software, participants voiced concerns about the challenges posed by unfamiliar CAD software and even basic tools such as PowerPoint. Nevertheless, the use of online tutorials and YouTube videos, along with daily practice, assisted them in overcoming these challenges. Participants noted the necessity of adapting to EdTech after transitioning from environments with limited exposure to digital resources. One participant shared: *In high school, we did not have access to online resources, so we had to adapt in varsity* (P2). This finding illustrates that students who lacked prior experience with technology often endured considerable adjustment periods after moving to digital learning environments. Such transitions can be particularly demanding when students are required to adopt unfamiliar tools and it may intensify feelings of inadequacy or discomfort.

Additionally, a preference for traditional learning methods was reported as a barrier (P2, P3, P6, P10, P14). Certain students expressed a preference for utilising physical books or studying offline, which indicates that technology may not appeal to all learners. P4 stated, *I prefer studying in books*, thereby highlighting that digital tools are not always perceived as necessary or superior to traditional methods. This preference reflects the diversity of learning styles among students and underscores

the importance of offering flexible options that accommodate individual learning needs and preferences (see Section 3.5).

Lastly, time management emerged as a challenge for effectively utilising EdTech tools. One participant referred to *poor time management*, indicating that the responsibility of self-regulation in online learning environments can be particularly daunting for some students. Digital learning often necessitates strong time management skills, and those without such abilities may struggle to fully engage with and benefit from provided resources.

Despite these challenges, participants acknowledged the positive aspects of EdTech tools. For instance, these resources were recognised for their utility in clarifying concepts during lessons and enhancing learning experiences. Students appreciated the ability to receive real-time feedback, access a diverse range of resources, and revisit lessons digitally, thereby demonstrating an acknowledgement of their potential, even amid challenges facing effective utilisation.

The consensus indicates that EdTech has the potential to complement traditional learning methods and enhance understanding, provided that appropriate support structures are established. This suggests that, with effective guidance and structured implementation, EdTech tools can function as valuable resources for student learning and engagement.

6.3.1.4 *Growth in TK*

This theme emphasises the evolution of technological competency by monitoring students' progress in knowledge and skills related to EdTech tools over time, particularly in the context of the EGDC1614 course content.

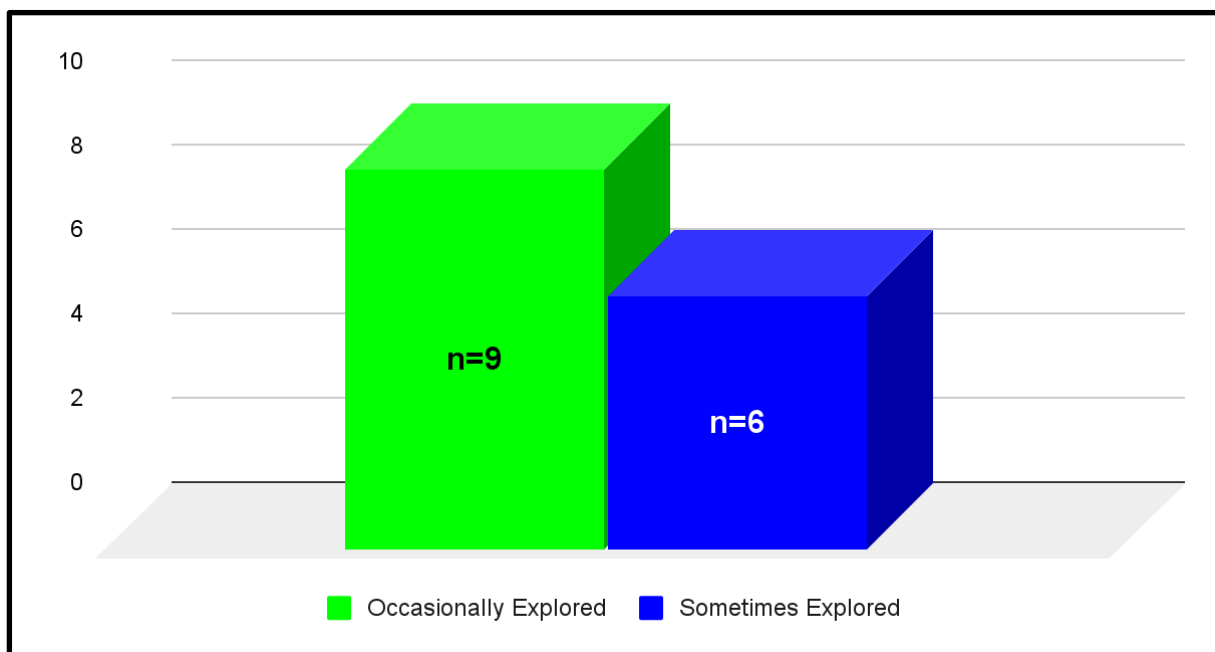


Figure 6.5: Exploration of new tools by first-year EGD student teachers

After the 10-week intervention, data indicates that all students who had enrolled for the EGDC1614 module started to explore new EdTech resources. More than half the participants ($n = 9$) reported that they occasionally engaged with these tools, while a notable subset ($n = 6$) indicated that they sometimes explored new EdTech resources. These findings underscore the role of EdTech in enhancing students' technology skills and confidence (see Section 4.2.1). Notably, the frequency of exploring new digital tools contrasts with the portrayal of Generation Z as frequent users of such tools in Chapter 3.

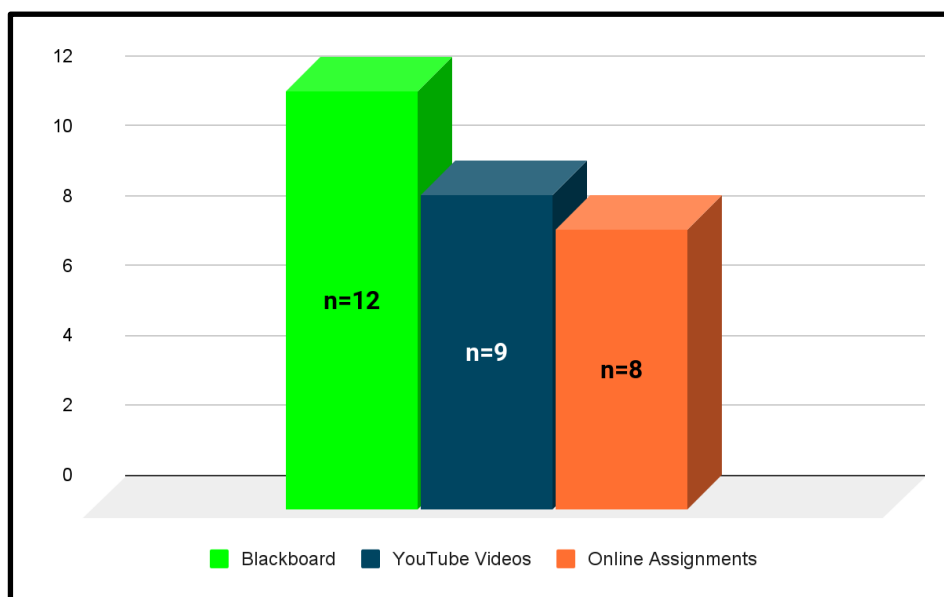


Figure 6.6: EdTech tools valued by first-year EGD student teachers

When considering the use of specific EdTech resources during the intervention, there was no significant change in students' perceptions regarding the value of these tools, as discussed in Section 6.3.1.1. Blackboard (n = 12), YouTube videos (n = 9), and online assignments (n = 8) continued to receive generally positive feedback.

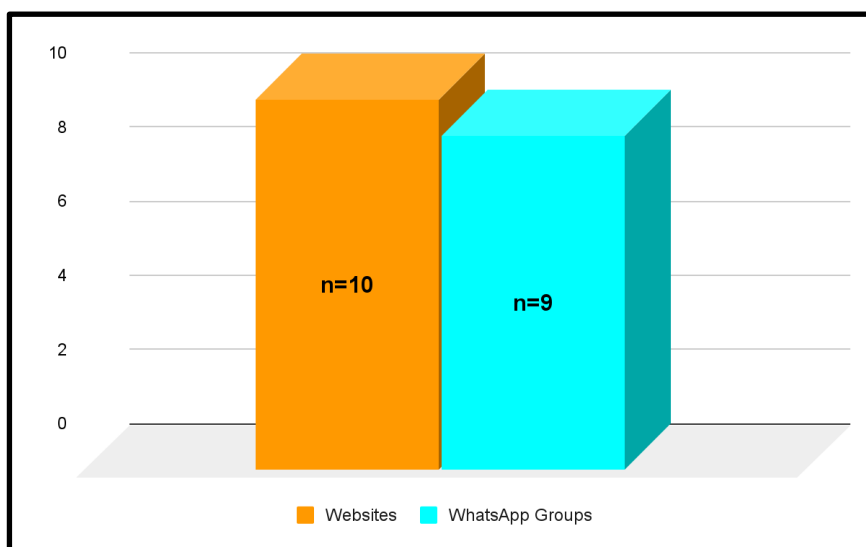


Figure 6.7: EdTech tools identified by first-year EGD student teachers as having a negative impact

In contrast, websites (n = 10) and WhatsApp groups (n = 9) were identified as problematic tools that elicited the highest levels of dissatisfaction. This dissatisfaction likely stems from usability issues, content concerns or technical performance problems that disrupted the learning experience. Although Section 4.2.5.2 addressed technical challenges in integrating digital tools, it does not specifically examine the dissatisfaction associated with these particular resources.

Resources such as explanatory videos, e-notes, interactive assignments and CAD drawing tools received mixed feedback, with some students finding them effective while others encountered challenges. This suggests a need for further customisation or targeted support to enhance usability. Students consistently acknowledged that digital resources facilitated their learning by offering ease of access and promoting flexible learning environments (P7, P9, P10), which aligns with the observations in Chapter 3 regarding contemporary students' adeptness at quickly accessing information because of their digital fluency.

Students were also asked to reflect on the impact of EdTech devices on their teaching and learning experiences. The majority of participants (P4, P5, P11, P12, P13, P14, P15) reported that using devices in lessons positively influenced their learning experiences, particularly in terms of engagement and their comprehension of topics. They highlighted that technology helped to keep them informed of digital tools, enhanced their skills (for example, in using Microsoft PowerPoint for engineering drawing), and motivated them to work on both digital platforms and in physical formats.

However, some participants (P3, P7, P8) expressed concerns that device usage in lessons could be counterproductive or detrimental if not implemented judiciously. They noted that, while technology had its benefits, its misuse could impede the learning process and excessive reliance on devices may hinder effective engagement with the material. Alternatively, a subset of participants (P1, P2, P7, P9, P10) indicated that device usage did not significantly affect their learning experiences.

Despite initial apprehensions regarding the negative effects of EdTech, all 15 participants acknowledged by the end of the 10-week intervention that EdTech had enhanced their learning. They cited the ease of access to information and resources (P7, P9, P10, P12) as essential for allowing them to work at their own pace and improve their understanding. Participants particularly valued the capacity to access

information conveniently, at any time and from any place, thereby emphasising that digital learning environments offer flexibility and convenience while facilitating efficient information retrieval for self-paced learning.

Students also noted that the flexibility of self-paced learning contributed to their academic success. They appreciated having access to materials outside of lesson time, which supported their time management and alleviated stress (P2, P6, P19), thereby echoing the emphasis on student-centred, adaptive learning in Education 4.0 referred to in Chapter 4. Furthermore, students valued recorded lessons (P9, P11, P12), which not only deepened their understanding but also increased their confidence and expertise regarding the subject matter. This flexibility enabled them to review materials multiple times to ensure comprehensive comprehension, which was especially beneficial for those who may have missed portions of the lesson. This finding aligns with the discussion of asynchronous learning tools, such as videos, in Sections 4.2.1 and 4.2.2, in the context of Education 4.0.

Participants reported that their exposure to EdTech resources had significantly enhanced their technological proficiency and confidence (P13, P14, P16, P18). They expressed feeling more prepared for future technological advancements and workplaces that require digital competencies. The diverse utilisation of EdTech resources to support their academic endeavours (P7, P16) facilitated the successful completion of assignments and projects.

6.3.1.5 *Confidence and satisfaction with EdTech tools*

This theme assesses the progression of students' confidence in utilising EdTech tools over time, as well as their overall satisfaction with these resources. It explores whether students perceived themselves as more competent and whether the tools met their expectations and requirements.

A significant number of participants ($n = 11$) reported feeling moderately confident about their ability to use various EdTech resources, including PowerPoint, SketchUp, Onshape, TurboCAD and AutoCAD, in the context of EGD. While many expressed comfort with these tools, they acknowledged that there was room for improvement and skills development. Additionally, a substantial subset of students ($n = 4$) identified as being somewhat confident and suggested that they would benefit from further support

and training to enhance their digital skills. This highlights a clear opportunity for developing digital expertise in the group.

The students agreed unanimously that they would be more effective with improved skills for utilising EdTech resources. Data indicate that proficiency in essential tools, such as online collaboration platforms (n = 14), recorded lectures (n = 13) and laptops (n = 13), significantly contributed to improving academic performance by facilitating content engagement, peer collaboration and task completion. This finding aligns with existing literature, which emphasises contemporary students' affinity for technology and proficiency with digital platforms (see Section 3.5).

The analysis, furthermore, indicates that the majority of students (n = 16) felt more engaged in courses that incorporated EdTech. Four participants noted that EdTech enhanced their connection to university activities, while 12 reported improvements in their connection to both peers and lecturers. These results correspond with the focus of the literature on blended learning and increased engagement (see Section 4.2.5.1). Opinions regarding the influence of online materials on lesson attendance were diverse: 12 disagreed that online resources led to skipping lessons, whereas four somewhat agreed.

Regarding preparedness and connectivity, 12 participants felt equipped to use EdTech upon entering the institution. However, the majority (n = 14) expressed a desire to enhance their skills with software such as MS Office and Google Apps prior to commencing their university studies.

Most students rated technical support positively by commending the availability of assistance in computer labs, the usefulness of tutorials and the overall effectiveness of the support provided (P1, P3, P4, P6, P10, P12, P13, P14, P15). Conversely, a smaller group of students had negative perceptions of technical support and primarily raised issues related to outdated lab computers that did not support the necessary software, thereby creating barriers to their learning (P5, P8).

6.3.1.6 *Lecturer's reflection*

The incorporation of TK in the teaching of EGD has become increasingly crucial in contemporary higher education, as emphasised by data from the lecturer questionnaire and self-reflection.

a) Impact of technology on teaching and learning

The integration of digital tools such as AutoCAD, OnShape, Blackboard and e-notes significantly enhanced both teaching methodologies and student learning experiences in EGD. Students indicated that CAD drawing tools were essential for their learning (see Section 6.3.1.1). These resources enable students to transition from traditional, manual drawing techniques to digital drawing, project simulations and online collaboration. By using platforms such as OnShape, students gain exposure to industry-standard software and provide them with authentic learning experiences that connect theoretical knowledge with practical application.

Furthermore, the implementation of an LMS such as Blackboard streamlined the tracking of student progress and cultivated structured and organised learning environments. Students benefited from digital access to learning materials, active participation in discussions and the ability to submit assignments electronically, which supports differentiated learning and offers greater flexibility. The use of these technologies helped educators minimise barriers to learning and enable students to concentrate on mastering key design principles instead of being impeded by logistical challenges. Blackboard emerged as the most highly valued EdTech tool by students, who deemed it essential for managing coursework and facilitating communication (see Section 6.3.1.1).

b) Challenges and adaptation

Despite the numerous advantages of technology integration in EGD instruction, several challenges were identified. A primary concern was the disparity in digital literacy levels among students. While many exhibited technological proficiency, a significant number (see Section 6.3.1.5) struggled to use digital tools, especially software such as AutoCAD and OnShape. This finding underscores the necessity of scaffolding technology instruction and ensuring that foundational digital skills are imparted before more advanced tools are introduced. Future initiatives should encompass digital literacy workshops at the outset of the course to equip all students with a fundamental understanding of the technologies they will be expected to employ.

Another challenge pertains to technology accessibility. Issues such as unreliable internet connections, outdated hardware and inadequate personal devices create barriers for certain students and hinders their full participation in the learning process.

Students echoed concerns about slow or unstable Wi-Fi and the limitations of obsolete computers that fail to support required software (see Section 6.3.1.3). To address these issues, providing alternative resources, such as offline assignments or institution-supported access to devices, would contribute to a more inclusive learning environment.

Additionally, concerns regarding academic integrity in online assessments surfaced, with digital platforms having the potential to be misused for plagiarism or cheating. Educators found that designing evaluations to focus on creativity and critical problem-solving can help mitigate these issues, as students are pushed to apply their knowledge in unique ways that are less susceptible to replication.

While some students identified smartphones as useful tools, they were also recognised as potential distractions. Educators' concerns about the disruptive effects of smartphones in the classroom were echoed by student feedback (see Section 6.3.1.1). This finding emphasises the need for careful consideration of how and when smartphones are integrated into the learning process, to ensure they enhance, rather than detract from, educational engagement.

c) Strategies for supporting students

To foster student engagement and learning in a digital environment, consistent technical support and structured feedback mechanisms have proven essential. Providing real-time troubleshooting and assistance ensures that technical difficulties do not hinder the teaching process. Moreover, opportunities for peer learning have been particularly effective. Implementing peer mentoring programmes that involve more digitally proficient students assisting their classmates, fosters collaboration and alleviates the anxiety some students experience when they have to adapt to new technologies.

The significance of feedback through digital platforms cannot be overstated. Systems such as Blackboard facilitate structured feedback loops and enable students to stay on track with assignments and receive timely guidance from instructors. This organised approach was instrumental in maintaining student engagement and focus, despite the challenges associated with adapting to new technologies. This effectiveness was corroborated by student feedback (see Section 6.3.1.4). However, it is important to recognise that not all students benefit equally from available tools

(see Section 6.3.1.2). Educators must remain responsive to student feedback and be adaptable by considering modifications or replacements for tools that do not adequately meet student needs.

The integration of technology in EGD instruction enhances student learning outcomes and aligns educational practices with industry standards, albeit while presenting challenges, such as digital literacy disparities and accessibility issues. Educators can effectively address these challenges by prioritising digital skills development, providing robust support and promoting collaborative learning. In summary, remaining adaptable and responsive to the rapidly evolving technological landscape is essential. Educators must assess students' technological needs to ensure that all learners benefit, thereby creating a dynamic and engaging educational environment that meets the demands of modern engineering.

6.3.2 Pedagogical knowledge

This section will explore the diverse dimensions of students' learning experiences by emphasising the learning environment, the effects of digital tools and resources and the effectiveness of pedagogical strategies. Through a comparative analysis of data collected from the pre-intervention questionnaire (see Appendix D, Section 4) and the post-intervention questionnaire (see Appendix E, Section 3), three key themes emerged: 6.3.2.1 Learning environment, 6.3.2.2 Digital tools and resources and 6.3.2.3 Pedagogical strategies. Each theme underscores distinct aspects of students' interactions with their learning environments, the digital resources utilised and the teaching strategies implemented throughout the intervention.

Figure 6.8 provides an overview of the three themes identified within the PK framework and indicates which subsidiary research questions were addressed by each theme.

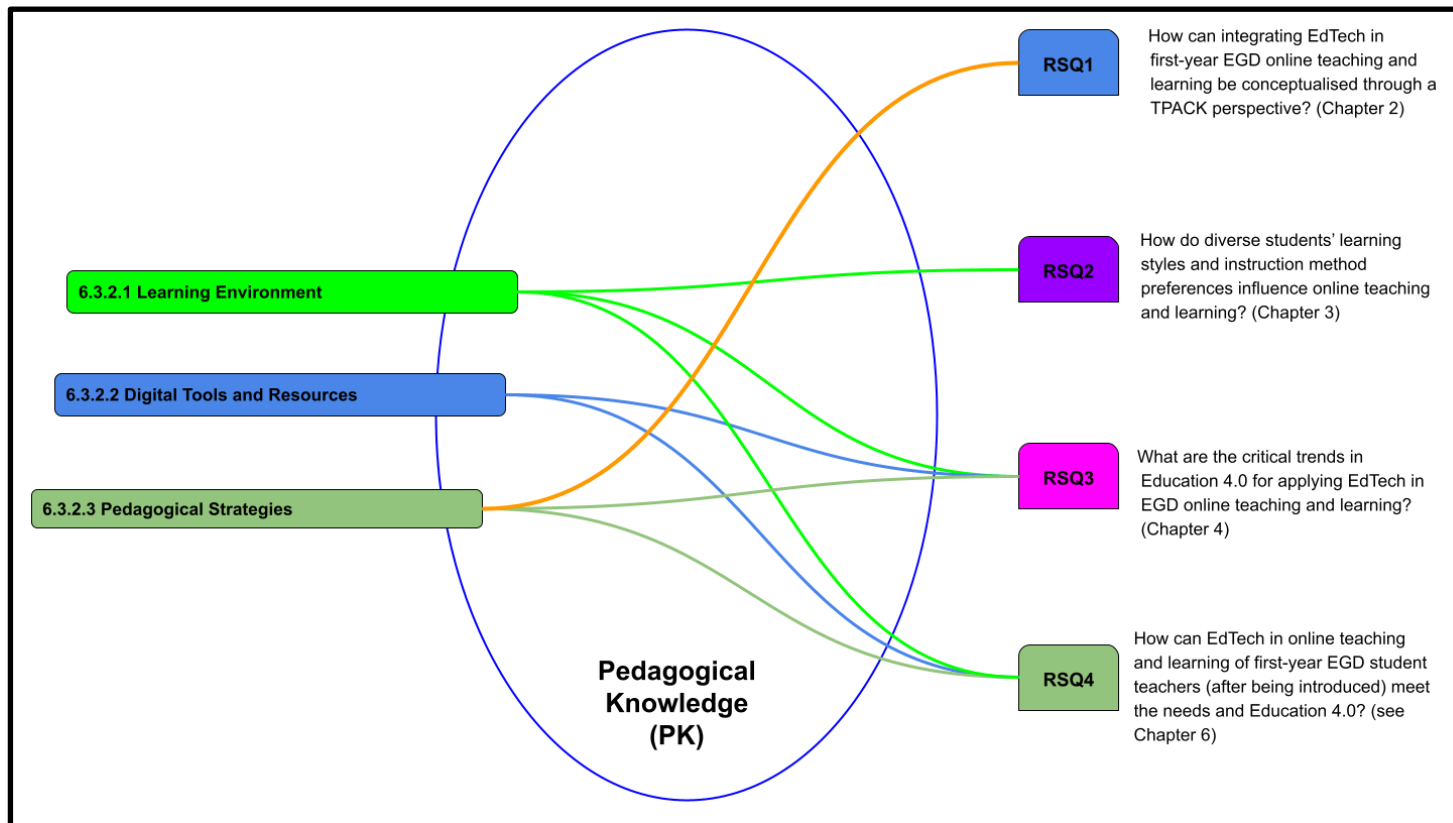


Figure 6.8: TPACK description areas and themes obtained from thematic analysis answering the subsidiary research questions

6.3.2.1 *Learning environment*

This theme examines the various learning environments that students favour and how these environments – whether physical, digital or hybrid – affected their engagement with course content and their overall success. It emphasises the significance of an effective learning space for promoting student engagement and facilitating achievement.

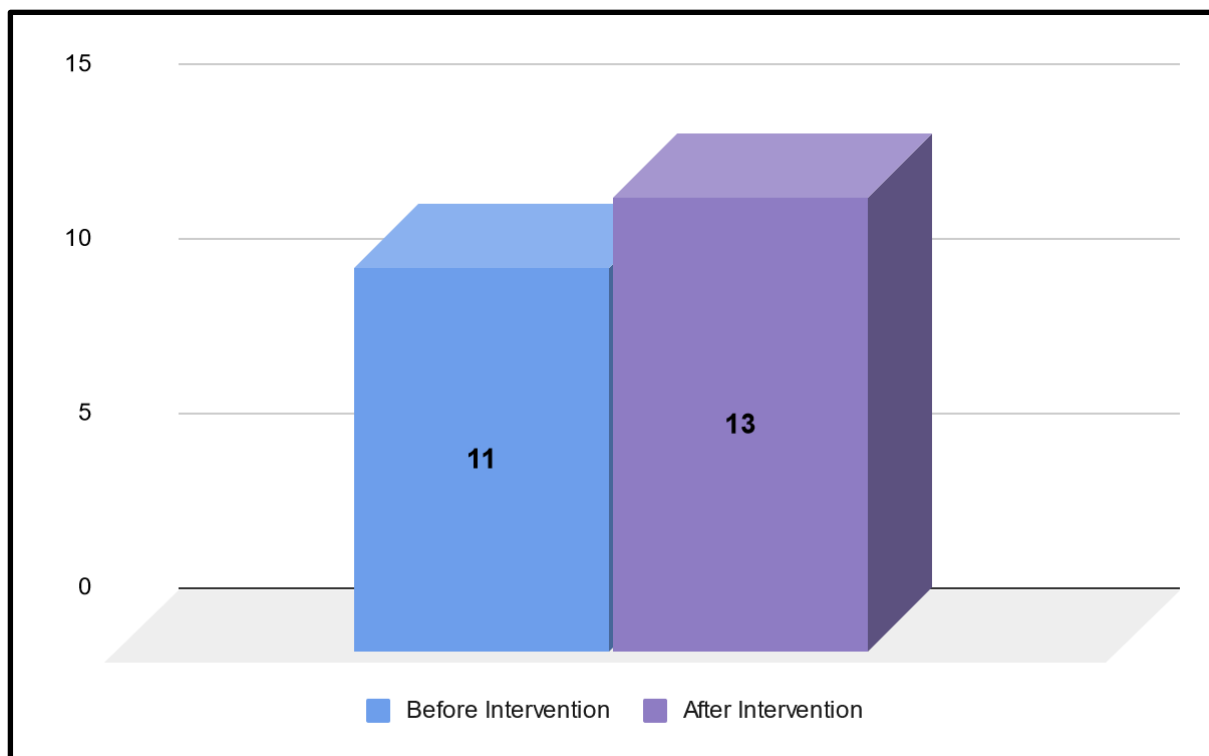


Figure 6.9: Bar diagram indicating learning environment preferences of first-year EGD student teachers

In Figure 6.9 it appears that first-year EGD student teachers, by being exposed to learning formats (i.e., face-to-face, fully online and HyFlex), developed a deeper understanding of their learning needs and preferences. Initially, 4 first-year EGD participants had expressed no preference regarding learning format; however, by the end of the intervention, all students articulated a distinct choice, namely HyFlex (Question 3.1 in Appendix E). This transition from majority face-to-face to majority HyFlex suggests that engagement with both in-person and online components during the online learning and teaching process contributed to a more nuanced awareness

of their individual learning preferences, as supported by the literature (see Section 4.2.4).

The findings reveal a notable shift in first-year EGD students' preference for blended learning (HyFlex), with an increase from 11 out of 19 students prior to the intervention to 13 out of 15 students afterwards. This shift reflects a rising acceptance of blended learning as students gained greater proficiency with digital tools – a characteristic aligned with the technological adaptability of contemporary students obtaining online attributes (see Section 3.5). The increased preference underscores the value students assign to balancing in-person interaction with digital resources, which emphasises the relevance of flexible learning environments discussed in Section 4.2.1. The possible trend towards blended learning highlights the need for education institutions to develop adaptable models that cater to diverse learner needs and align with the principles of Education 4.0, which advocate for a student-centred approach and the integration of technology in pedagogy.

In contrast, the preference for entirely online learning remained largely unchanged, with only 1 student selecting this option in both surveys. Thus, it appears that fully online environments may be less appealing, as many students appreciate the structure and interaction afforded by face-to-face components. This aspect aligns with the literature on the importance of interpersonal engagement in learning (see Section 4.2.2).

The data, furthermore, indicate that the integration of digital and blended learning in the educational context is still in its developmental stages: 10 first-year EGD student teachers reported that their courses were not blended, while 5 noted the inclusion of blended elements in some modules. Despite progress in higher education institutions towards blended/HyFlex environments, 11 of the first-year EGD student teachers had not yet experienced fully blended or fully online learning environments, which highlights the need for further efforts to align education practices with the demands of Education 4.0.

Given the benefits of blended and online learning, such as flexibility, accessibility and the development of digital competencies, higher education institutions are encouraged to expand these formats. Doing so will improve the preparedness of students to face the demands of a digital future while enhancing their learning experiences.

6.3.2.2 *Digital tools and resources*

This theme focuses on the way digital tools and resources are integrated in teaching and how they influence students' comprehension of course material. Additionally, it examines the effectiveness of these tools in enhancing learning outcomes and how well they are utilised in instructional practices.

Table 6.4: Influence of the integration of EdTech in teaching practices

Theme	Description
Positive perceptions	• The majority of participants (n = 14) agreed that EdTech resources effectively enhanced comprehension of EGD concepts.
Enhanced participation	• Tools such as email, Blackboard, and WhatsApp ○ Boosted confidence in resolving issues; ○ Facilitated quick communication with peers and lecturers; and ○ Encouraged proactive help-seeking and collaboration, thereby increasing overall engagement.
Improved accessibility and learning flexibility	• Students appreciated the ability to: ○ Learn at their own pace, from anywhere; and ○ Engage more deeply with course material due to flexibility and accommodation of diverse learning styles.
Dynamic and collaborative learning	• Introduction of new digital tools kept learning engaging. • Opportunities for peer collaboration enhanced engagement and comprehension further.
Increased engagement and interest	• Enriched learning experiences were engaging and easier to manage. • EdTech tools made class more dynamic and enjoyable. • Improved technological skills enhanced overall class interaction.
Task efficiency and focus	• Complete tasks efficiently, especially in practical activities such as CAD drawings. • Increase their investment of time and effort, thereby fostering deeper interest in course content.
Simplified administration	• Tools such as Blackboard ○ Simplified submission processes; and ○ Smoothed administrative tasks, allowing students to focus on learning.

The findings in Table 6.4 on the integration of digital tools and sources in teaching practices, with special emphasis on the influence on student comprehension and engagement, will now be discussed.

a) Pre-intervention perspectives

Before the 10-week intervention, the majority of student participants (n = 14) expressed agreement on the efficacy of EdTech resources for enhancing their understanding of school-related or EGD concepts. This positive feedback aligns with the literature discussed in Chapter 3, which reports that contemporary students are familiar with digital tools and online platforms (see Section 3.3). However, five students expressed neither agreement nor disagreement, suggesting a need for additional support or exposure to help these students realise the benefits of EdTech fully. These students may still be acclimating to digital tools or may require tailored approaches to address their specific needs.

b) Post-intervention perspectives

After the intervention, students expressed strong consensus on the value of EdTech tools for promoting engagement with course content, particularly in the EGDC1614 module. Participants (e.g., P1, P2, P4) emphasised that tools such as email, Blackboard and WhatsApp significantly enhanced their confidence to resolve academic challenges. These tools facilitated seamless communication with peers and lecturers and encouraged proactive help-seeking behaviour and peer collaboration. This aligns with the concept of social learning environments that is central to Education 4.0 (see Section 3.5).

Students (e.g., P3, P7, P9, P15) referred to the accessibility of learning resources, which enabled them to study at their own pace and convenience. EdTech tools accommodated diverse learning styles and schedules and boosted their interaction with the material. This flexibility aligns with the emphasis of Education 4.0 on personalised and technology-enhanced learning environments (see Section 4.2). Additionally, students (e.g., P6, P1) reported improved technology skills and engagement and that EdTech tools introduced new and enjoyable learning experiences, fostered improved interaction with classmates and enhanced overall course participation.

c) Motivation and efficiency of EdTech for first-year EGD student teachers

EdTech tools were also identified as motivating and inspiring students (e.g., P6, P10, P11, P12, P14) to complete tasks more efficiently, particularly practical applications

such as CAD drawings. Platforms such as Blackboard simplified administrative tasks, while digital tools promoted collaboration and deepened interest in the course content.

d) Influence of specific EdTech tools on student learning in EGDC1614

Blackboard and CAD tools: Blackboard emerged as the most impactful tool, with 9 first-year EGD student teacher participants reporting potential enhancement of learning and 6 reporting slight enhancement. CAD tools (e.g., PowerPoint/Onshape) similarly received positive feedback, with 7 participants reporting that they found EdTech beneficial and 5 reporting slight benefits. However, some students (n = 5) struggled with the complexity of CAD tools, which indicates a need for additional training.

YouTube videos: YouTube videos proved to be effective because they offered visual explanations, with 6 students recognising their potential to significantly enhance understanding and 7 reporting moderate benefits. One student, however, experienced confusion, which underscores the importance of clear and structured content.

Interactive assignments: Interactive assignments elicited diverse results. While 8 students found them helpful for understanding EGD concepts, 5 reported that they significantly hindered learning, possibly because of issues with content clarity or format intuitiveness.

Explanatory videos, e-notes and WhatsApp groups: Feedback on these tools was diverse. While some students appreciated the structure and usability of e-notes and explanatory videos, others reported minor obstructions. Similarly, WhatsApp groups facilitated collaboration for 6 students but posed distractions for 8, which reflects the challenges of using informal communication platforms in academic settings.

Online assignments: Online assignments were generally effective, with 5 students finding them helpful and 4 reporting slight hindrances, often because of technical issues or stress.

e) Influence of EdTech on learning engagement of first-year EGD student teachers

The use of EdTech tools had a predominantly positive influence on student engagement, as reported by most participants (e.g., P3, P4, P5, P7, P8, P11, P15,

P16, P17, P19). Students indicated that these resources enhanced their ability to apply new knowledge, interact with course material and actively participate in class discussions. This feedback aligns with the literature on the role of flexible, technology-based learning environments in fostering engagement.

Some participants (e.g., P2, P9, P10) reported varied experiences: While EdTech tools improved convenience and focus, they did not significantly affect their overall learning experience. Additionally, technical issues occasionally reduced engagement (e.g., P13), which indicates the need for robust technical support.

Students expressed confidence in their lecturers' ability to integrate EdTech effectively, with all respondents agreeing (n = 14) or strongly agreeing (n = 5) on this point. While the positive reception of EdTech tools reflects their potential to enhance learning, the challenges associated with specific tools emphasise the need for careful design and implementation.

Overall, tools such as Blackboard, CAD software and YouTube videos were instrumental in enhancing student learning and engagement in the EGDC1614 module. However, the challenges associated with interactive assignments and WhatsApp groups expose areas for improvement in content delivery and platform usability. The findings emphasise the importance of striking a balance between user-friendly design and instructional support to maximise the effectiveness of EdTech tools. Moving forward, focused training initiatives and the refinement of digital resources will be essential to ensure their sustained efficacy for enhancing teaching and learning.

6.3.2.3 *Pedagogical strategies*

This theme examines the teaching methods that incorporate EdTech and indicates which strategies are most beneficial for student learning. It explores the effect of student feedback on the effectiveness of different approaches and suggests ways to improve the integration of technology in pedagogical strategies.

a) Pedagogical strategies that enhance learning through EdTech resources

The baseline questionnaire revealed diverse use of EdTech tools, with video lectures being the most preferred (n = 6). Students highlighted the flexibility of video lectures; however, an over-reliance on this format risks fostering passive learning and potential

overwhelm. Tutorials (n = 4) and interactive simulations (n = 3) emerged as valuable for promoting active learning, for enabling students to apply knowledge and engage more directly with concepts. Online assessments, providing immediate feedback, supported understanding further.

Despite these benefits, the reduced use of collaborative tools, which had been received well before the intervention, is concerning. Reviving their usage could strengthen communication and problem-solving skills. The first-year EGD student teachers emphasised the need for a balanced pedagogical approach that integrated video content with active and collaborative strategies to enhance engagement and learning outcomes. This approach aligns with the collaborative principles of Education 4.0 (see Section 4.2.2).

b) Pedagogical benefits of EdTech resources

After the 10-week intervention, participants reflected on the pedagogical benefits of EdTech resources used in the EGDC1614 module. Students (P1, P2) valued the accessibility of support channels such as email, Blackboard and WhatsApp and found them effective for engagement. They appreciated the flexibility provided by laptops and EdTech tools, which facilitated interactive and autonomous learning. Also, participants (P3, P4, P5) highlighted video content as engaging and effective for skills enhancement, thereby demonstrating the power of multimedia in learning (see Section 6.3.1.4).

While learning new platforms and software was motivating for some participants (P6, P7, P9, P15), the transition from manual to online drawing posed challenges due to interface complexities. Interactive YouTube videos, however, were widely appreciated for making learning more enjoyable and boosting motivation. Some participants (P8, P10, P11, P12, P14) reported that EdTech tools enhanced their understanding of topics and shifted their perspectives on EGD, to demonstrate their capacity to improve comprehension and offer diverse viewpoints.

Overall, the data underscores that EdTech tools foster comprehension, engagement, motivation, skills development and support. However, adapting to new software interfaces remained a challenge for some students.

c) Online assessments using EdTech tools

While EdTech tools offered flexibility and accessibility, technical issues, particularly poor internet connectivity, hindered the user experience for some participants (P1, P8, P10). These challenges align with the need for improved infrastructure and technical support highlighted in Section 4.2.5. Addressing these barriers is essential for maximising the potential of EdTech resources, especially in a challenging South African higher education landscape.

The ability to complete tasks at their own pace was identified as a major advantage for students (P3, P5, P10, P13). Online submission of assignments eliminated the need for travel and multiple-choice assessments were perceived as user-friendly. Tools such as Onshape enriched the learning experience by making content more engaging (see Section 6.3.2.2).

While EdTech tools offered simplicity, convenience and interactive learning, technical issues occasionally detracted from their effectiveness. Students generally found these technologies to be efficient and engaging, though reliable access remains a concern.

d) Qualitative suggestions and feedback on EdTech implementation

First-year EGD student teachers' suggestions for improving EdTech integration highlighted four key areas:

- **Gradual introduction and patience:** Participants (P1, P12, P15) recommended phased implementation of EdTech, with orientation programmes to reduce frustration. They also emphasised the need for educators to be patient when they address technical challenges.
- **Access to resources:** Participants (P6, P7, P8, P9, P11) stressed the importance of providing updated computers and functional software to ensure equitable access.
- **Blended learning approaches:** A combination of online and in-person lessons was suggested (P3) to cater for diverse learning preferences and to enhance flexibility.
- **Continuous technological adaptation:** Participants (P13, P14) called for universities to stay current with technological advancements and to establish feedback systems to address ongoing challenges.

In conclusion, the findings underscore the importance of a balanced pedagogical strategy that integrates video content, active learning and collaborative tools. While EdTech resources significantly enhance comprehension, engagement and skills development, challenges such as technical barriers and adaptation to new tools must be addressed. Recommendations to improve the overall student experience with EdTech include providing better infrastructure, gradual implementation, blended learning approaches and continuous technological updates.

6.3.2.4 *Lecturer reflection*

The reflections of both lecturers were integrated into the following aspects: Instructional strategies and student-centred learning, Technological integration and digital literacy, Challenges in accessing technology and digital tools, Assessments and feedback mechanisms, Learning environment preferences and engagement, and Ethics considerations when using technology.

These aspects underscore the transformative potential of EdTech tools such as AutoCAD, OnShape and Blackboard for enhancing conceptual understanding and engagement in EGD, while also highlighting critical challenges, such as digital literacy gaps, technology access inequalities and ethics considerations in digital learning environments. Through a blended learning model and targeted support strategies, these integrated reflections aim to address these challenges and promote equitable and impactful learning experiences for all students.

a) Instructional strategies and student-centred learning

Incorporating student-centred, active learning strategies has been pivotal in teaching EGD. Digital tools such as AutoCAD and OnShape have significantly enhanced students' ability to visualise complex shapes, thereby improving their spatial reasoning and overall conceptual understanding. Feedback from students supports this approach, with many participants highlighting that EdTech tools positively affected their grasp of EGD concepts (Section 6.3.2.2). Additionally, platforms such as YouTube and PowerPoint were identified as valuable resources for reinforcing course material (Section 6.3.2.3).

b) Technological integration and digital literacy

Technology plays a critical role in facilitating the visualisation of abstract concepts in EGD. Platforms such as Blackboard and digital modelling software have introduced interactive avenues for exploring design principles. This is evident in the student feedback, where a 100% satisfaction rate was recorded for the effective use of EdTech tools by lecturers (Section 6.3.2.2). Moreover, tools such as CAD and Blackboard were particularly noted for their significant effect on learning outcomes (Section 6.3.2.2).

However, disparities in digital literacy among students remain a challenge. While some adapt quickly, others require additional support. Feedback indicates a need for more guidance in using advanced tools such as CAD (Section 6.3.2.3). To address this need, implementing digital literacy workshops could equip all students with the foundational skills required to thrive in a technology-driven learning environment.

c) Challenges to accessing technology and digital tools

A notable barrier to effective EdTech integration is unequal access to technology. Some students reported lacking personal devices or reliable access to updated lab equipment, which hindered their ability to fully engage with course content. This was reflected in student data, where participants cited poor internet connectivity and outdated hardware as significant impediments to utilising EdTech tools (Section 6.3.2.2). Five students specifically noted that technical difficulties limited their engagement with interactive assignments.

To create a more equitable learning environment, strategies such as laptop loan programmes and improved access to well-equipped computer labs were proposed. Addressing these disparities is essential to ensure all students can participate fully and effectively in the course.

d) Assessments and feedback mechanisms

The integration of formative assessments, peer reviews and structured rubrics facilitated timely and personalised feedback for students. Many participants valued the real-time feedback provided by digital platforms, which helped them identify areas for improvement and enhance their engagement. This aligns with the reflection that described the role played by Blackboard in fostering effective communication and interaction between peers and lecturers (Section 6.3.2.2).

Balancing digital assessments with opportunities for hands-on, creative problem-solving is critical. This ensures students continue to develop essential critical thinking and problem-solving skills, rather than becoming overly reliant on digital tools.

e) Learning environment preferences and engagement

A blended learning model that combines traditional in-person instruction with digital tools proved to be effective for teaching EGD. This approach offers flexibility and allows students to engage with materials at their own pace through both classroom and online resources. While some students initially struggled to adapt to digital learning environments, targeted support measures helped to mitigate these challenges.

Blended learning not only enhances active participation but also accommodates diverse learning preferences. This model is instrumental for equipping students with the skills and adaptability needed to meet the evolving demands of modern education.

f) Ethics considerations when using technology

The integration of technology in teaching necessitates a focus on ethical considerations, including plagiarism and academic dishonesty. Students acknowledged the ease of accessing digital resources but emphasised the importance of using these tools responsibly. Incorporating assessments that promote originality and critical thinking is crucial for fostering ethical engagement with EdTech tools while encouraging deeper learning.

In conclusion, the integration of pedagogical strategies with digital tools in EGD demonstrates significant potential for enhancing student engagement and learning outcomes. However, challenges such as digital literacy gaps, unequal access to technology and the need for flexible learning environments require attention to ensure equitable benefits for all students. By addressing these challenges and maintaining a balanced approach that combines digital tools with traditional problem-solving activities, educators can create an inclusive, engaging and effective learning experience. This refined integration will improve the preparedness of students to meet the technological demands of modern engineering environments, while fostering critical skills that are essential for success.

6.3.3 Content knowledge

This section investigated the utilisation and efficacy of EdTech resources in the module EGDC1614, with an emphasis on students' perceptions and experiences regarding EdTech resources. The baseline data assessed the overall effectiveness of EdTech resources in facilitating learning, particularly their function in elucidating intricate concepts and improving interaction with an LMS. The reflection data offer insights into the extent to which particular EdTech tools facilitated students' comprehension during the course. The combination of these datasets provides valuable insights into the comprehensive effects of educational technology on learning in this module. Each theme corresponds with specific questions in Appendices D and E, thereby focusing on students' experiences and evaluations of the EdTech resources in the context of CK acquisition.

Figure 6.10 gives an overview of the five themes that were identified in the CK description area and which of the subsidiary research questions were answered by each theme.

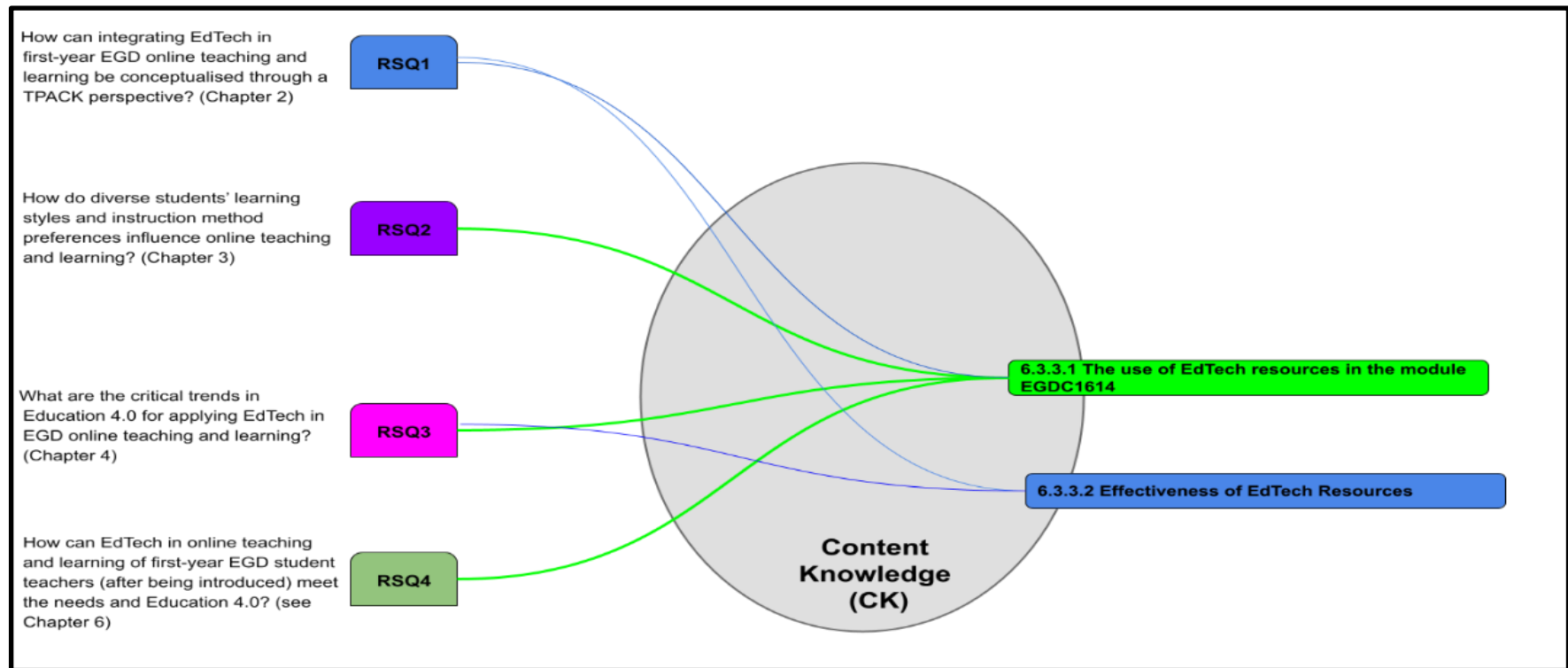


Figure 6.10: TPACK description areas and themes obtained from thematic analysis answering the research questions

6.3.3.1 *The use of EdTech resources in the module EDGC1614*

This theme evaluates whether students found EdTech tools useful for their learning experience in the specific context of the EGDC1614 module. In Figure 6.11 general perceptions of EdTech tools are compared with how effectively they were applied in this course, with a particular focus on the reflection data insights regarding course-specific tools.

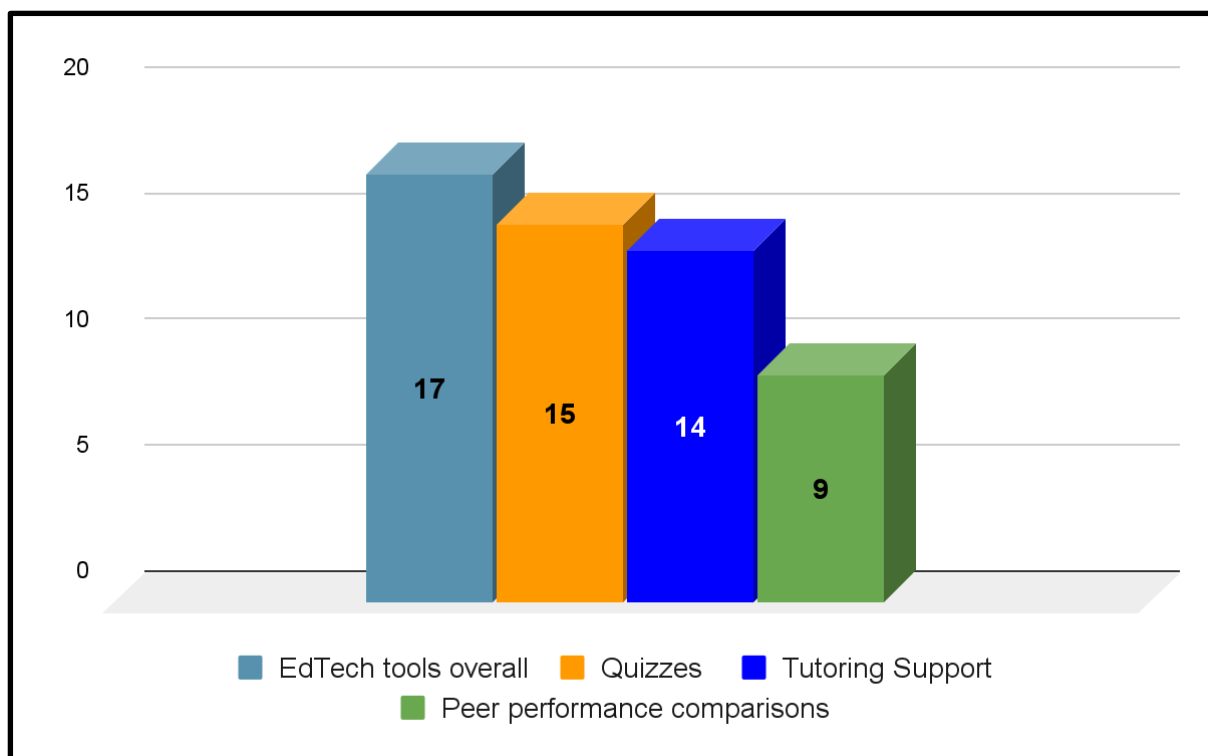


Figure 6.11: Bar diagram indicating the use of EdTech resources in the Module EGDC1614

As demonstrated in Figure 6.11, in total 17 first-year EGD student teachers appeared to be positive about EdTech resources being beneficial, by citing several key factors that contributed to their positive experiences. These factors include the enhancement of teaching and learning processes, improved accessibility to online lessons and resources and a strong preference for the convenience that technology provides. Moreover, students expressed appreciation for increased access to assistance and information, which played a crucial role in their understanding of complex concepts, which ultimately led to improved academic outcomes. However, the study also

identified challenges, including ongoing technical difficulties and the need for continuous training to utilise EdTech tools effectively.

Data from the baseline questionnaire revealed that a subset of students (P1, P2, P5, P9, P10, P12, P13, P14, P15, P16, P18, P19) often relied on online platforms such as Google and YouTube to clarify concepts and complete assignments, which underscores the significance of these resources for their academic success. Conversely, another group (P3, P4, P6, P7, P8, P17) did not engage with online resources, possibly because of a preference for traditional methods or limited access to technology. Understanding these dynamics may assist in overcoming barriers and promoting wider adoption of EdTech tools.

After the 10-week intervention, tools such as OnShape, ArchiCAD and YouTube were reported to have significantly enhanced students' comprehension of complex concepts, particularly visualising challenging topics and bridging knowledge gaps (P1, P2, P5, P6, P7, P8, P9, P15). These resources were particularly beneficial for the development of practical skills and visual acuity (P3, P11). Furthermore, students (P4, P10) appreciated the availability of diverse support channels (e.g., Blackboard, email, WhatsApp) for clarifying concepts and obtaining assistance as needed. They (P13, P14) also acknowledged that individual effort, in conjunction with the tools and resources provided, contributed to improving academic performance. This applicability of EdTech tools aligns with the information provided in Section 4.2.2, where the effectiveness of digital tools for enhancing learning outcomes by offering multimedia and interactive elements conducive to understanding complex subjects, particularly in EGD, was established.

Overall, the findings indicate that most students considered EdTech tools to be very valuable for gaining insights into complex topics, enhancing performance and accessing online resources. The use of Blackboard as an LMS garnered strong interest among students, particularly regarding personalised academic tools. The data emphasise the benefits of EdTech tools for fostering student engagement and interaction, as discussed in Section 4.3, which highlights a shift towards student-centred learning paradigms (Sections 6.3.1.4 and 6.3.2.2). When appropriately integrated, digital tools can enhance student autonomy and engagement, which are key principles of Education 4.0. Personalised quizzes and practise questions were

rated favourably (n = 15) and empowered students to concentrate on their strengths and weaknesses. Similarly, recommendations for academic resources (n = 14), including tutoring and skills-building workshops, were valued, which suggests that students recognise the significance of additional support for their academic achievements.

Additionally, it appears that first-year EGD student teachers (n = 15) desired timely updates on their academic progress. They demonstrated an interest in alerts concerning declining performance and real-time feedback via visual dashboards. These features facilitate continuous monitoring and enable informed decision-making.

The results on a four-point Likert scale indicate that students were in favour of implementing a tracking system to monitor their performance. Specifically, a significant portion of students expressed enthusiasm for automated tracking of attendance, with 5 students selecting *Extremely interested* and 8 students selecting *Very interested*. These numbers reflect a notable level of interest in attendance tracking compared to other features. This enthusiasm may stem from the perceived benefits of improved accountability and support for academic success.

In conclusion, the data underscores a clear student preference for personalised academic tools that offer tailored feedback, real-time progress monitoring and adaptive learning strategies. Features such as quizzes, dashboards, degree tracking and performance alerts were particularly valued for their contributions to maintaining academic momentum and facilitating timely interventions. While comparative analyses of peer performance and course recommendations received moderate interest, automated attendance tracking ranked lowest, which indicates that students prioritised tools that influence their learning experiences and outcomes directly. Consequently, education institutions should focus on enhancing personalised academic support and real-time feedback mechanisms, to align with student preferences and optimise academic performance.

6.3.3.2 *Effectiveness of EdTech resources for teaching and learning content*

This theme measures the overall effectiveness of EdTech tools in enhancing student learning outcomes. Figure 6.12 captures how well these resources supported

understanding of the course content and highlights students' critical reflections on their practical value.

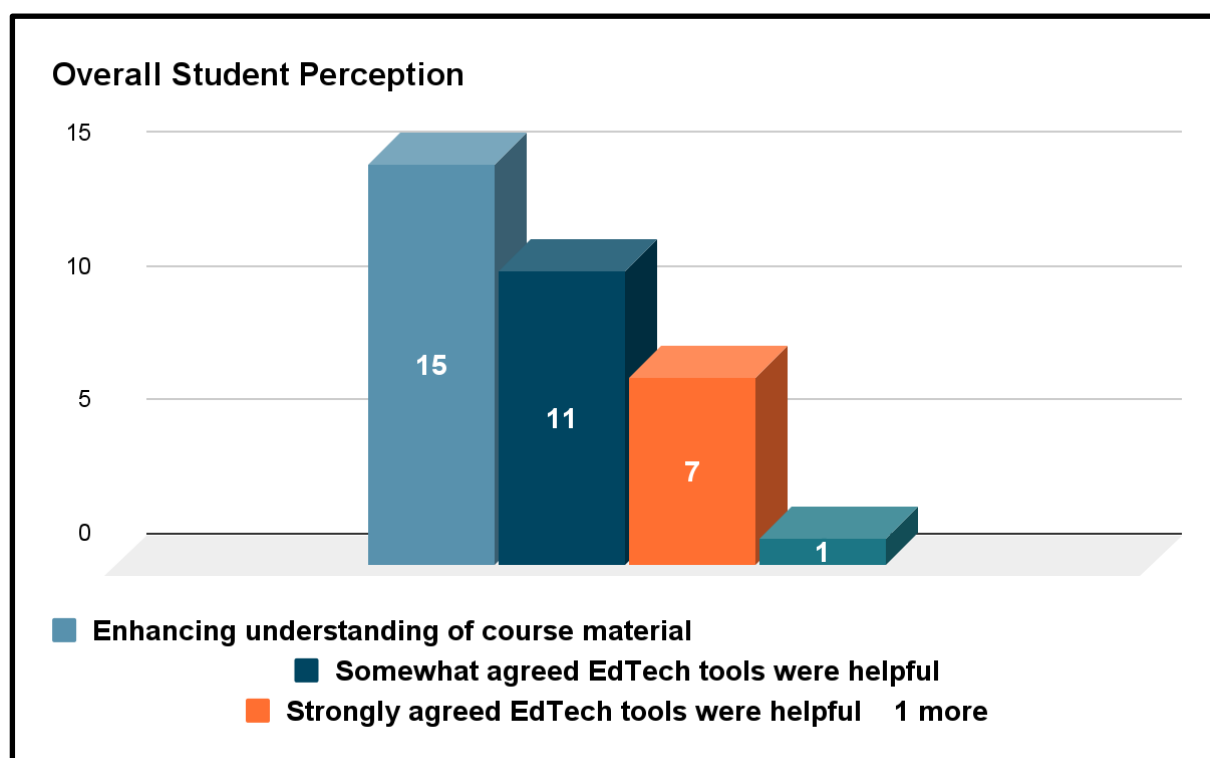


Figure 6.12: Bar diagram indicating the effectiveness of EdTech tools for enhancing student learning outcomes

Figure 6.9 indicates the overall effectiveness of EdTech tools for enhancing student learning outcomes. It captures how well these resources supported understanding of the course content and highlights students' critical reflections on their practical value. It is evident that most first-year EGD student teachers ($n = 15$) had been satisfied with EdTech tools and found them helpful for understanding course content before, but were more satisfied after the intervention. This aligns with the research reported in Section 4.2.2 of Chapter 4, which highlights how digital tools, particularly multimedia components such as videos and online platforms (YouTube), can significantly enhance student comprehension of complex topics. These tools allow for improved engagement with course material, especially for visual or practical subjects such as EGD.

While the results indicate that 7 students strongly agreed and 11 students only somewhat agreed that the tools were helpful, there remains significant room for

enhancement. This discrepancy points to a potential gap in the effectiveness of these tools for certain students. To address this situation, incorporating more interactive features, personalised learning options, or improved alignment with individual learning styles could increase overall student satisfaction and lead to stronger agreement. Section 4.2.5.2 also highlights that some students may face barriers in fully utilising EdTech tools because of technical issues, insufficient support, or disconnection with specific content, which may explain why a few students expressed dissatisfaction. Additionally, while only one student officially disagreed, it is important to investigate the underlying reasons for their sentiment. Factors such as poor design, lack of accessibility, or misalignment with content could lead them to perceive that the tools did not significantly enhance their understanding. Further exploration in these areas could help ensure that all students fully benefit from the digital resources provided.

The overall effectiveness of these EdTech tools (after the 10-week intervention), identifying their strengths and areas where they might be less effective. The feedback of most first-year EGD student teachers (n=13) indicates a positive influence of EdTech tools. Students found these tools helpful for understanding difficult concepts, especially when they used videos and online resources such as YouTube. EdTech tools were considered sufficient for most topics, although some students acknowledged that certain topics might still require face-to-face instruction. Some feedback suggests that, while EdTech tools were helpful, they were not sufficient on their own to obtain proficiency.

Students highlighted the need for practical, hands-on experience to grasp certain concepts fully. Section 4.3 discusses the shift toward student-centred learning in digital environments, which encourages using interactive and practical experiences, combined with digital tools, to create a more holistic learning experience. This section supports the idea that EdTech tools should complement rather than replace practical, face-to-face instruction.

The effectiveness of EdTech tools appears to vary depending on the subject matter. Two students indicated that EdTech tools had limited effect; they expressed that additional practical lectures and assignments were needed. They suggested that EdTech tools primarily served to highlight the availability of resources rather than significantly enhancing learning. However, the analysis shows that EdTech tools are

generally well-received, with most students finding them beneficial for understanding and engagement. The effectiveness of these tools can be subject to the type of content being taught and the students' learning preferences. A balanced approach that combines EdTech tools with practical experiences and face-to-face interactions is recommended to maximise the benefits for all students

6.3.3.3 *Lecturer reflection*

In reflecting on the implementation of CK and technology integration in EGD during the 10-week intervention, several themes emerged that underscore both the strengths and challenges of this teaching methodology. These experiences resonate with the TPACK framework, which emphasises the synergy between deep content expertise and the practical application of digital tools to enhance student learning.

a) CK and teaching strategies

The role of CK in EGD is important, particularly for effectively conveying complex topics such as orthographic projections, pictorial drawings and CAD applications. Various strategies were employed to enhance the accessibility of these concepts. For example, decomposition techniques were utilised to break down complex tasks into manageable components. This method facilitated a deeper understanding of intricate design elements by engaging students in hands-on tasks that reinforced their comprehension.

We also emphasised the importance of integrating real-world examples to bridge the gap between theoretical knowledge and practical applications. This strategy appears to be particularly effective for demonstrating how design principles apply to engineering situations; it rendered the material more relatable and engaging for students. Additionally, implementing controlled design assignments to assess student understanding reinforced learning by compelling students to apply their skills in practical contexts rather than relying solely on theoretical constructs.

b) Integration of technology and digital tools

Technology integration played a pivotal role in modernising the pedagogical approach to EGD. Platforms such as Blackboard, OnShape, AutoCAD and other digital design tools were instrumental in content delivery to facilitate interactive learning and assess student progress. These tools provided an avenue for delivering real-time feedback,

efficiently monitoring student progress and offering supplemental multimedia resources, such as videos and tutorials, that enriched traditional teaching methods.

Virtual simulations and digital tools helped bridge the divide between abstract design concepts and their practical applications. For instance, students could utilise digital simulations to visualise and interact with complex engineering designs – a feat that would be challenging to achieve through conventional teaching methodologies. However, this integration also highlighted a substantial challenge: digital literacy. Some students encountered difficulties with CAD software and other digital applications, which identified an imperative need for foundational training in these tools to maximise their efficacy in the classroom.

c) Inequitable access challenges to technology

While technology significantly enhanced the teaching of EGD, it also raised ethics concerns regarding equitable access to digital resources. Certain students lacked access to personal laptops and the institutional computers tended to have outdated hardware or slow internet connections. This disparity created challenges for students who lacked adequate resources, hindered their ability to complete assignments efficiently and caused frustration and possible learning gaps. From an ethical standpoint, ensuring that all students have equal access to the tools and technologies they need is critical, which remains a priority for future interventions.

In conclusion, the intervention provided valuable insights into the significance of integrating CK with technology in EGD education. Although challenges arose, it can also present opportunities for growth and improvement, particularly in enhancing digital literacy and ensuring equitable access to resources.

6.4 SELF-REFLECTION OF RESEARCHER & LECTURER ON 10-WEEK EDTECH INTEGRATION OF FIRST-YEAR EGD MODULE BASED ON REFLECTIVE CYCLE OF GIBBS

The reflection practice of the first-year EGD lecturer and researcher for the EGDC1614 module will be presented in Sections 6.4.1–6.4.6.

6.4.1 Level 1: Description of 10-week intervention for first-year EGD module

During the first week of the EGDC1614 module, I implemented an instructional approach, using Blackboard as the LMS, to deliver course content and track student progress. The session, held face-to-face in the EGD lab, included an introduction to the module, course content and Blackboard navigation with a PowerPoint presentation and a walkthrough of the Blackboard module course. The module aims to equip students with the knowledge, skills and attitudes they need to demonstrate, identify and apply EGD techniques, focusing on introductory engineering and geometrical and mechanical drawings in the FET phase.

As the lecturer, I provided the instructional and welcome video, designed PowerPoint slides and guided students in navigating Blackboard and completing tasks independently. I have ensured all module information was available on Blackboard, disseminated weekly announcements, monitored participation using QR codes and an Excel spreadsheet, tracked task completion and provided assignment feedback. Students accessed digital resources, followed instructions, scanned QR codes for attendance and monitored their own progress via Blackboard.

6.4.2 Level 2: Views on 10-week intervention for first-year EGD module

Before the course started, I experienced a mix of excitement and responsibility. I was eager to implement Blackboard as a central tool for the intervention, to showcase the welcome video and observe students' reactions. At the same time, I felt accountable for ensuring that all instructional materials were clear, accessible and conducive to positive learning experiences.

Throughout this phase, I maintained focus and diligently monitored student engagement and progress on Blackboard using the QR code system. Providing timely feedback reinforced my confidence in supporting students with the necessary resources to complete their tasks independently.

By the end of the intervention, I was relieved and experienced a sense of accomplishment. The successful implementation of teaching strategies and positive student responses validated my efforts. I was particularly satisfied with the structured and organised learning environment, which fostered student engagement and learning outcomes.

In reflecting on this experience, I believe I successfully integrated digital technology into foundational teaching practices. Blackboard was an effective LMS and facilitated self-directed learning, progress tracking and meaningful feedback. The systematic approach enriched students' learning experiences. From the students' perspective, initial feelings of curiosity and adjustment possibly gave way to increased confidence and comfort as they engaged with Blackboard and completed tasks. Structured feedback and regular updates offered clear guidance and a sense of support.

Looking back, I believe students appreciated the clarity and organisation Blackboard provided. As they adapted to the technology-driven approach, they possibly recognised the benefits of digital tools for independent learning. The consistent updates and feedback reinforced their understanding, kept them on track and contributed to a positive learning experience.

Initially, I was confident about using Blackboard to facilitate student engagement, given its robust tools for content delivery and tracking progress. However, I was slightly apprehensive about how well students would adapt to using the platform and following self-directed tasks. During the session, I noticed varying levels of student engagement, which left me both encouraged by their enthusiasm and concerned about those struggling with the digital aspects of the module.

6.4.3 Level 3: Evaluation of 10-week intervention for first-year EGD module

The evaluation of the 10-week intervention approach for the EGDC1614 module employed Blackboard as the LMS, which served as the central hub for all instructional activities. Several strengths contributed to the success of the 10-week intervention:

- **Centralised resources and communication:** Blackboard provided a unified platform where students could access resources, assignments and feedback. Weekly announcements ensured that communication was clear, timely and consistent.
- **Progress monitoring and support:** Participation was monitored via QR codes and task completion was tracked on Blackboard. This system enabled us to identify students who needed additional support or intervention.

- **Independent learning facilitation:** Students were encouraged to complete technology-related tasks independently, which fostered self-directed learning skills. Weekly updates and feedback supported this process and helped students to stay engaged and on track.
- **Organised and structured approach:** The use of Blackboard was methodically planned. Clear instructions and easily accessible resources contributed to a well-structured learning environment.

6.4.3.1 *Challenges encountered with the 10-week intervention approach*

Despite its strengths, the intervention faced a few challenges:

- **Familiarity with technology:** Not all students were equally comfortable with Blackboard or adept at using digital platforms. Some required additional guidance to navigate the interface and complete tasks.
- **Access and equipment issues:** A few students experienced difficulties accessing Blackboard because of limited device capabilities or connectivity challenges, which impacted their ability to participate fully in the intervention.

6.4.3.2 *Implementation and successes of the 10-week intervention approach*

Implementing Blackboard and leveraging digital resources proved to be highly effective. Students accessed the necessary information, completed independent tasks and benefited from regular updates and feedback. Monitoring participation via QR codes and tracking progress through Blackboard created a systematic approach to teaching and learning. The success of the intervention stemmed from:

- Well-organised use of Blackboard, which ensured clarity and accessibility of resources;
- Timely feedback and consistent updates, which kept students motivated and informed; and
- Active student engagement, which contributed to the smooth functioning of the course.

6.4.3.3 *Areas for improvement of the 10-week intervention approach*

While the intervention was largely successful, some areas could have been smoother:

- **Adjustment period:** The initial phase required students to adapt to the Blackboard platform and its features. For some, this adjustment took longer because of the steep learning curve caused by unfamiliar technology and a more autonomous learning model.
- **Technical support:** Additional orientation sessions or troubleshooting support could have mitigated challenges and ensured a more seamless transition to the new system.

6.4.3.4 *Contributions and engagement of the 10-week intervention approach*

As the lecturer, my contributions included:

- Preparing and delivering the instructional and welcome video;
- Designing PowerPoint slides and providing clear instructions for independent tasks;
- Ensuring all necessary resources were uploaded and accessible on Blackboard; and
- Monitoring participation via QR codes, tracking progress and offering timely feedback through weekly updates.

Students contributed by:

- Actively engaging with the digital resources and functionalities of Blackboard;
- Completing assigned tasks independently, scanning QR codes for attendance and tracking their progress on Blackboard; and
- Adjusting to the autonomous and technology-driven approach, which was integral to the module's success.

6.4.3.5 *Reflection on outcomes of the 10-week intervention approach*

Reflecting on this intervention, I consider it to be a successful demonstration of integrating digital technology in foundational teaching practices. Blackboard proved to be a comprehensive tool for facilitating self-directed learning, tracking progress and providing meaningful feedback.

From the students' perspective, while initial feelings of curiosity and adjustment were probably present, their confidence and comfort increased as they navigated Blackboard and completed tasks. The clear structure, consistent feedback and regular updates provided a supportive framework and ensured a positive overall learning experience.

At the end of the 10 weeks, I experienced a profound sense of achievement. The effort I had invested in designing and delivering the course was validated by students' engagement and ability to adapt to the new learning environment. This intervention exemplified how technology, when integrated thoughtfully, can enhance outcomes of both teaching and learning.

6.4.4 *Level 4: Analysis of 10-week intervention for first-year EGD module*

The analysis of the integration of Blackboard as the LMS in the EGDC1614 module exposed a structured and organised learning environment that aligned with the module objectives/outcomes (see Appendix I). By leveraging digital tools such as PowerPoint presentations, QR codes and Blackboard analytics, I successfully tracked student participation, monitored progress and provided timely feedback. This approach contributed to a positive learning experience for most students while highlighting areas for improvement, particularly those related to addressing the disparities in students' digital proficiency. These efforts align with the first level of the TIM and underscore the importance of foundational support to ensure equitable access to learning resources and success in a digitally enhanced education setting.

6.4.4.1 *Strengths of the 10-week intervention approach*

The systematic use of Blackboard created a centralised platform where students accessed study guides, notes and weekly updates while staying informed about assignments and objectives. Frequent announcements provided clarity on what to

expect and helped students anticipate the path ahead. This transparency was well received, as students expressed an appreciation for understanding the course structure and schedule.

PowerPoint presentations enhanced comprehension and memory retention and played a pivotal role in both academic and practical learning. For example, a guest lecturer's workshop on EGD drawings that used PowerPoint added depth to the students' understanding of the subject matter.

Tracking participation through QR code scanning and monitoring progress on Blackboard effectively captured student engagement. While some students initially hesitated to use mobile devices for QR code attendance, consistent reinforcement of the method demonstrated its value and gradually shifted students' attitudes to a more positive view of the technology.

Students were encouraged to engage independently with technology-related tasks, which fostered self-directed learning and improved their digital proficiency. This approach aimed to develop the critical technological skills required for both academic success and future professional contexts.

6.4.4.2 *Challenges encountered in the 10-week intervention*

Despite these strengths, several challenges emerged:

- **Digital literacy gaps:** Although students belong to Generation Z, significant shortcomings in digital literacy were evident. Some struggled to navigate Blackboard and required additional support, which emphasised the need for targeted interventions to enhance students' technological skills.
- **Initial resistance:** A few students were reluctant to use certain digital tools, such as QR code scanning. They cited various reasons for their hesitance. Over time, however, persistent encouragement helped overcome these barriers.
- **Attendance incentives:** While the Blackboard attendance records incentivised participation, there was a risk that students might attend class

solely to gain attendance points rather than to actively engage in the learning process.

6.4.4.3 *Key insights into and adjustments of the 10-week intervention*

Through this activity, I gained valuable insights into effective instruction in a technologically advanced setting:

- Using an informational and welcoming video on Blackboard set a positive tone, provided clear guidance and helped students to navigate the LMS and understand the course framework.
- Timely feedback, supported by rubrics, memoranda and Blackboard grading tools, proved essential for first-year students. These tools offered clarity and direction, particularly for students who were adjusting to a new learning environment.
- Weekly attendance records on Blackboard not only motivated students but also served as a tool for self-assessment that enabled them to monitor their engagement.
- Integrating academic and practical components demonstrated the efficacy of blended learning and combined digital resources with traditional teaching to create a holistic educational experience.

6.4.4.4 *Reflection and moving forward*

In hindsight, the intervention exemplified how Blackboard can be a comprehensive tool for supporting self-directed learning, tracking progress and providing feedback. However, the challenges highlight the importance of scaffolding students' digital literacy skills early on in the course to ensure a smoother transition to autonomous, technology-driven learning.

Additionally, I observed that first-year students thrived with structure and clarity and maintained consistent communication and feedback. While the integration of digital tools was largely successful, future iterations of the module should include more robust orientation sessions and ongoing support to address the varied levels of technological proficiency.

Overall, this experience underscored the potential of blending traditional and digital methodologies to create an engaging and effective learning environment that prepares students for the demands of a contemporary education setting.

6.4.5 Level 5: Conclusion of 10-week intervention for first-year EGD module

The 10-week intervention in the EGDC1614 module demonstrated the effectiveness of integrating Blackboard as an LMS for delivering course content and tracking student progress. The instructional approach fostered a structured and well supervised learning environment that enabled students to access essential information, complete assignments independently and receive timely feedback. This approach contributed to a productive and engaging learning experience.

However, challenges emerged because of students' varying levels of digital literacy. Some students were reluctant to embrace digital technology and struggled with basic technical aspects, detracting from the learning process. Time was spent addressing these issues and certain students did not initially perceive the value of incorporating digital tools into their education.

6.4.5.1 Key insights into and adjustments of the 10-week intervention

- **Digital literacy development:** A confirmable gap in students' digital literacy highlighted the need to dedicate time to build these skills. Future iterations should prioritise an enhanced orientation to Blackboard and digital tools to ensure that all students can confidently engage with the platform and resources.
- **Showcasing the value of technology:** To overcome reluctance, a focused effort should be made to demonstrate the broader benefits of using digital technologies. This could include an introductory video emphasising the practical and long-term advantages of using these tools, for both the module and students' future careers.
- **Tailored training and support:** Providing extensive training and continuous support throughout the course could foster greater comfort and familiarity with digital tools. This would help address resistance and

improve students' ability to engage effectively in a technology-driven learning environment.

- **Customised resources:** Conducting a thorough review of online resources during the planning phase and incorporating customised materials for specific topics could enhance the learning experience further.
- **Pilot testing of tools:** Implementing pilot tests for digital tools before their introduction into the module could help identify potential issues and ensure a smoother learning experience for students.

6.4.5.2 *Future recommendations for the 10-week intervention*

- **Digital skills integration:** Embed foundational digital competencies in the curriculum, such as creating and editing videos and utilising digital tools, to prepare students for technology-enhanced education and careers.
- **Emphasising practical applications:** Illustrate how knowledge and skills gained from digital tools can be applied in other subjects and real-world contexts to reinforce the value of the intervention.
- **Consistent feedback and communication:** Continue leveraging the features of Blackboard, such as announcements, rubrics and attendance tracking, to provide clear guidance and maintain student engagement throughout the course.

In summary, while the intervention successfully introduced digital tools and methodologies, to maximise its effect, it would be essential to address possible gaps in digital literacy and resistance to technology. By refining the instructional approach and incorporating targeted support measures, future iterations of the module can enhance the integration of digital technology into teaching and learning further.

6.4.6 Level 6: Comprehensive action plan of 10-week intervention for first-year EGD module

To address challenges encountered and to create a more inclusive, supportive and effective learning environment, the following action plan integrates strategies to improve infrastructure, foster innovation and enhance student engagement.

6.4.6.1 *Enhancing digital infrastructure and accessibility*

- **Mobile CAD labs:** Provide portable, high-performance laptops with CAD software such as OnShape pre-installed. These mobile labs can be loaned to students or shared among classrooms to ensure equitable access to essential tools.
- **Wi-Fi enhancement zones:** Establish dedicated areas on campus with enhanced connectivity. These zones can be achieved with the support of tech companies. Reliable internet access will ensure that all students can participate fully in online learning.

6.4.6.2 *Innovative teaching and support strategies*

- **Gamified learning modules:** Develop interactive, gamified modules to teach CAD and other technical skills. Gamification can simplify complex concepts and make learning engaging and competitive.
- **Peer mentorship programme:** Introduce a programme in which experienced students or alumni provide guidance to current students. Peer support fosters collaboration and builds confidence in navigating digital tools.
- **Virtual helpdesks:** Set up real-time chat and video support systems, complemented by AI-powered chatbots, for handling routine queries. This would ensure that students have access to timely assistance for technical or academic challenges.

6.4.6.3 *Feedback and reflection for enhanced learning*

- **Interactive feedback tools:** Utilise tools such as Kahoot! or Padlet to make feedback sessions more engaging and interactive, by providing immediate responses and encouraging dynamic participation.
- **Reflection workshops:** Host regular workshops at which students can reflect on their learning experiences and challenges. Use design thinking methods to identify solutions and foster continuous improvement.

6.4.6.4 *Collaboration and interdisciplinary learning*

- **Industry partnership projects:** Collaborate with local industries to offer hands-on projects that integrate real-world applications of technical skills to enhance students' employability and practical understanding.
- **Interdisciplinary hackathons:** Organise events where students from various disciplines collaborate to solve complex challenges using digital tools. This activity could promote innovation and encourage creative problem-solving.

6.4.6.5 *Ongoing professional growth*

- **Digital training workshops:** Provide continuous professional development opportunities for both students and educators to ensure they remain proficient in emerging digital tools and technologies.
- **Time management seminars:** Offer workshops focused on practical strategies for balancing academic workloads, personal commitments and real-world assignments, to equip students with essential life skills.

6.4.6.6 *Leveraging data and analytics*

- **Learning analytics dashboards:** Create dashboards that provide real-time student engagement and performance insights. Use this data to identify and support students needing additional assistance proactively.

- **Predictive analytics:** Employ predictive tools to forecast resource needs, such as tutoring or technical support, to ensure a proactive rather than reactive approach to challenges.

6.4.6.7 *Implementation steps for future improvements*

- **Detailed Blackboard orientation:** Conduct sessions focused on troubleshooting common technical issues, with supplemental quick-reference guides and instructional videos for students with lower digital literacy.
- **Emphasise the value of technology:** Develop an introductory video that illustrates how digital tools can enhance learning and career readiness. Showcase how module skills transfer to other subjects and real-world applications.
- **Regular check-ins and feedback:** Schedule frequent check-ins to monitor student comfort with Blackboard and address issues promptly. Leverage rubrics and real-time feedback to build clarity and confidence.
- **Alternative participation methods:** Explore solutions for students who cannot use QR codes, record their attendance manually or use alternative participation-tracking mechanisms.

By implementing this multifaceted action plan, future iterations of the module can overcome barriers, build digital literacy and foster an environment of continuous learning and innovation. This approach would address current challenges and equip students and educators with the tools they need to excel in a dynamic, technology-driven academic landscape. Ultimately, it aims to create a more seamless, inclusive and enriching educational experience for all participants.

6.5 EXPERT PANEL

As explained in Sections 5.9 and 5.10, an expert panel of five members were invited to participate in this study to discuss, add valuable inputs and validate the findings, conclusions and guidelines for EGD lecturers when integrating EdTech. The panel discussion, which took place on 29 October 2024 from 17:00 to 18:00, was introduced

with a 10-minute PowerPoint presentation, after which the panel engaged in a discussion. The panel agreed that the presentation of the findings and proposed guidelines for EGD lecturers of the study appeared to be applicable in the context of EGD modules in general. However, the most prominent concerns derived from the expert panel are the following:

- The reference to and applicability of the concept of Generation Z in the South African higher education landscape;
- The limitations of the study with regard the small sample size and the case study methodology; and
- The applicability of the 10-week intervention at other South African higher education institutions, with special reference to engineering faculties housing the EGD module, where this module usually has classes with large numbers of students.

These aspects were addressed at the finalisation of the thesis and in reporting the study limitations (see Section 7.7) and future research suggestions (see Section 7.8).

6.6 REVIEW OF DATA TRIANGULATION

According to the literature, data management is integral to data analysis. Managing a database is viewed as a challenge (Nourani et al., 2022) because a researcher has to comprehend the data and locate the description to illustrate the concept or phenomenon under study – in this study, the integration of EdTech in the first-year EGD module for student teachers based on the TPACK model.

In this study, I decided to handle the data management as a display of data triangulation in a table (see Table 6.5). The horizontal rows present the main dimensions of integrating EdTech in the first-year EGD module for student teachers based on TPACK. Columns 2 and 3 summarise the qualitative data that were complemented by quantitative, triangulated data from the pre-intervention first-year EGD student teacher Questionnaires 1 and 2, respectively. Column 4 provides the qualitative, triangulated data of the second-year EGD lecturer, and Column 5 provides the self-reflection data of the first-year EGD lecturer. Column 6 contains data from the expert panel's reflections on the study findings and guidelines. In addition, the text and

font colours visually enhance the interpretation, synthesis and evaluation of the matrices.

The text in Table 6.5 uses colour-coded highlighting to indicate the level of confirmation across multiple data sets: unhighlighted text represents data confirmed by one data set, yellow highlighting indicates confirmation by two data sets, purple highlighting signifies confirmation by three data sets, and green highlighting denotes confirmation by four data sets.

Text without highlighting indicated data confirmed by one data set

Text highlighted by Yellow indicated data confirmed by two data sets

Text highlighted by Purple indicated data confirmed by three data sets

Text highlighted by Purple indicated data confirmed by four data sets

Table 6.5: Summary of the data analyses triangulation results of first-year EGD student teachers/lecturers/expert panel

Dimensions of EdTech integration in first-year EGD module	Student Questionnaire 1  Result (Dataset 1)	Student Questionnaire 2  Result (Dataset 2)	Lecturer questionnaire  Result (Dataset 3)	Self-reflection of lecturer  Result (Dataset 4)	Expert panel  Result (Dataset 5)
Technological knowledge					
Guidelines					
Establish digital infrastructure readiness	• More resources to help undersupplied higher education students.	• Working without a laptop is challenging, as it limits access to resources, complicates assignment submission and causes students to miss academic notifications. A laptop with suitable software greatly simplifies and enhances the learning experience. • Network issues, unreliable campus Wi-Fi and outdated devices hinder work and submissions. Challenges were managed by using personal data and ensuring timely preparation. • Support was available, and outdated lab		• Limited Wi-Fi and outdated computer labs hindered students' use of EdTech tools, causing frustration and affecting learning outcomes, especially for students who did not have personal laptops. • Suggestions include improving Wi-Fi, modernising computer labs and creating mobile CAD labs with preloaded laptops to ensure equitable access.	

		computers and a shortage of personal devices created learning barriers for students unable to afford laptops. Updating lab equipment is essential for equity. • Technical issues, especially internet connectivity, created challenges despite the easy-to-use tools. • Properly functioning computers and updated software are needed to ensure all students can access essential online resources.			
Provide comprehensive digital literacy training	• Students identified the need to improve their skills for using online tools, learning systems, laptops, e-textbooks and simulations, to improve their learning outcomes. • Students expressed moderate confidence about using tools such as PowerPoint, SketchUp and AutoCAD, indicating room for improvement.	• Students struggled with new software, but tutorials and practise, including YouTube videos, helped them to adapt. Advanced tools such as CAD and OnShape require time, experience and high-performance devices. • Students emphasised the need for an orientation session to familiarise themselves with EdTech tools • Allocating more time to help new learners	• Demonstrate software use, encourage sharing of recorded files for personalised learning, monitor submissions and start with simple tasks and gradually progress to complex ones, such as 3D modelling assemblies.	• Students struggled with digital tools because of varying experience levels, which highlights the need for additional digital literacy training. • Efforts should focus on creating digital literacy training and professional development for educators to manage and promote electronic resources. • Proposed introductory workshops should aim	

	- Many students wished they had been better prepared to use basic software such as MS Office and Google Apps before starting their studies. - Students found digital tools intimidating and would benefit from guidance and support to use them effectively.	adapt to EdTech tools was recommended.		to enhance digital literacy and build confidence in students and educators about using digital resources.	
Monitor and address access gaps		Understand technical difficulties, introduce technology gradually and make learning with tech tools enjoyable.	- Ensure tasks are engaging, monitor the class for risks and clearly outline rules that apply to everyone. - Lecturers should plan for technical issues, consider cultural differences, maintain a moderate pace, engage students and manage time effectively. Accessibility, student feedback and flexibility in teaching are essential. Minimise distractions such as unnecessary notifications.	Integrating digital rubrics delivers detailed feedback and enhances student outcomes.	
Considerations					
Continuous technical support	Offer technical support and guidance to ensure effective use.	Provide strong technical support to ensure device usability.	Plagiarism can be managed with Turnitin software and cheating can be prevented	Provide accessible technical support that utilises tutors to assist students effectively.	

	• Effective use of these tools helps educators and IT support to address challenges. • Provide support with additional resources to clarify complex concepts. • Enhance infrastructure for seamless use of digital tools and applications.	• Offer support to improve the functionality of personal devices. • Ensure technical support for digital tools used for academic tasks. • Good support is available, but responsiveness and availability should improve. Regularly elicit student feedback to identify support gaps. • Provide technical support to resolve issues during online assessments. • Be understanding of students' technical difficulties and train educators to handle issues effectively. • Access to timely assistance is essential for effective learning.	through gadget-free exams and 3D cameras for thorough monitoring.	• Address challenges such as outdated desktops and slow Wi-Fi and highlight the need for infrastructure upgrades. • Propose providing mobile CAD labs, improving Wi-Fi and creating virtual help desks with AI chatbots that provide real-time assistance. • Present workshops to enhance tutors' and educators' troubleshooting skills and digital tool proficiency. • Provide training and toolkits to guide students in using digital tools, emphasise structured support and skills development.	
Expand access to digital tools	• Irregular use of digital tools suggests restricted access or lack of engagement. • Having materials online may be a barrier for some students. • Recorded lessons allow students to access content	• Students prefer on-campus resources for their consistent availability and reliability. • Expanding YouTube tutorials and online platforms can improve support for student learning.	• Ensuring that essential digital tools are readily available for teaching integration is crucial for effective education. • Digital and online tools should be chosen carefully according to their availability and	• Establish mobile CAD labs with high-performance laptops, enhanced campus Wi-Fi zones and real-time help desks with AI chatbots and human tutors. • Outdated desktops, slow Wi-Fi and	

	conveniently and improves understanding for those with limited access to live sessions. • Address disparities in access by ensuring availability of a wide variety of digital tools. • Challenges arise from inconsistent access to digital tools. • Expand infrastructure to provide consistent connectivity and broader access to digital tools.	• While institutional technical support is rated adequate, students suggested improvements in responsiveness and availability. • Students appreciated institutional support systems and the consistent availability of digital resources (Section 3.4). • Multiple channels, such as recorded lectures and interactive quizzes, enhanced engagement with course content. • Ensuring the availability of the software and tools needed across courses promotes equity among students. • Expanding access to essential tools and instructional videos improves concept understanding and supports diverse learning needs. • EdTech tools provide adequate access to learning materials, but additional resources	alignment with teaching objectives. • Providing videos and interactive materials supports diverse learning styles and accommodates varying schedules and enhances inclusivity and accessibility.	reliance on computer labs stand in the way of students completing assignments, especially students who don't have personal laptops. • Modernise computer labs with updated equipment and better Wi-Fi and collaborate with institutional authorities to ensure equitable technological access. • Address gaps in students' digital literacy with training sessions to improve their ability to use EdTech tools effectively. • Introduce peer mentorship programmes in which tech savvy students help others and foster equitable access to digital tools and skills.	

		could improve outcomes further.			
Increase engagement with interactive resources	• Tools such as CAD software and multimedia simulations improve student engagement and understanding. • Interactive assignments, quizzes and explanatory videos foster active involvement. • Interactive learning tools are essential for engaging students how have had limited exposure to technology. • Efforts to provide access to essential resources help reduce usage inequalities. • Regular interaction with digital tools boosts interest and promotes deeper learning. • Digital and online resources are highly effective for creating engaging and interactive learning experiences.	• While EdTech tools were generally sufficient, adding more practical and interactive elements could enhance engagement further. • Interactive features were deemed crucial for better comprehension and application. • Blackboard, YouTube and explanatory videos significantly improved interaction with course content. • Interactive assignments and online assessments encouraged student involvement and increased understanding. • Quizzes and videos motivated students to engage with material. • Video lectures were appreciated for explaining complex topics in an interactive way. • EdTech tools increased engagement with course materials and fostered	• Digital tools such as AutoCAD, OnShape and ArchiCAD are employed to enhance student engagement and promote interactive learning. • Digital and online tools foster interactive engagement and improve comprehension using simulations and multimedia. • Virtual simulations and multimedia tools create interactive and immersive environments. • 3D modelling and printing engage students in experiential and project-based learning through digital tools. • Multimedia resources enhance engagement by creating dynamic learning experiences.	• Tools such as Visla and Renderforest were used to create interactive films with subtitles and explanations. • Students engaged with interactive electronic documents on Blackboard, by incorporating movies, notes, quizzes and homework via QR codes. • Digital tools enabled students to engage in constructive learning, building concepts and exploring applications. • Collaborative learning through EdTech promoted authentic engagement and deeper understanding. • Virtual help desks with real-time chat and video support to improve student interaction with learning resources are proposed.	

		motivation and deeper learning. • Collaborative activities and tools such as CAD software inspired teamwork and interaction among students. • Tools such as OnShape provided engaging platforms for interactive assessments. • Multimedia and interactive tools made online assessments more interesting and effective.			
Content knowledge					
Guidelines					
Customise digital tools for subject-specific learning			• Demonstrate software use, encourage recorded file sharing for personalised learning and monitor submission statistics to support student progress. • Break down complex concepts into smaller, manageable parts to enhance understanding. • Use case studies and scenarios to make learning more relatable and practical.	• Integrate videos and notes on Blackboard that cover assembly and pictorial drawings (e.g., isometric, oblique and one-point perspective) to support targeted learning. • Use tools such as Visla, Renderforest, TurboCAD and OnShape that are tailored for EGD, to help students develop skills in orthographic and pictorial drawing.	

			• Employ teaching tools and strategies that are designed to meet specific subject needs to improve effectiveness.	• Incorporate CAD tools such as OnShape alongside traditional drawing methods to combine digital and manual techniques in the curriculum.	
Offer personalised learning pathways				• Digital tools enables students to independently select and use resources suited to their learning needs, thereby promoting autonomy and personalised learning. • Recommended learning modules combine individual tasks with group projects to foster both personalised learning and collaborative engagement. • Platforms such as Feedback Fruits and automated email feedback can provide tailored recommendations to help students improve academic performance	
Balance hands-on and digital learning	• Suggested training programmes should aim to improve student confidence to use digital tools such as PowerPoint,	• Interactive simulations or virtual labs motivate students to study, thereby emphasising the need to integrate hands-on learning	• Digital tools such as 3D modelling and printing combine hands-on learning with simulations, thereby promoting experiential	• Combining face-to-face lessons, tutorials and online resources creates a structured and supervised environment and	

	SketchUp, OnShape, TurboCAD and AutoCAD, which are essential for integrating hands-on and digital learning in EGD. • Students prefer balanced environments that combine hands-on and digital learning, over fully online courses, which highlights the importance of interactive and blended learning settings. • Tutorials and simulations were identified as key strategies for engaging learning through digital and practical applications and providing meaningful and hands-on experiences. • Tutorials and interactive simulations were emphasised as effective methods for learning through digital resources and practical applications and ensuring engaging and hands-on experiences.	experiences with digital tools.	and project-based education. • Hands-on tasks are paired with digital tools such as AutoCAD and OnShape to enhance physical and virtual involvement in EGD. • Practical methods integrate EGD online platforms with physical drawing and design tasks to create an interactive learning experience. • Simulations and teamwork on platforms such as Blackboard support a blended learning model.	improves engagement, performance and satisfaction. • Weekly schedules integrating face-to-face and online resources provide a thorough and well-organised approach to education. • Mixed methodologies in assessments incorporate both traditional and digital drawing tools to highlight the seamless integration of modern technology with established practices. • In-person tutoring and virtual collaboration sessions foster a balanced environment and promote both individual and group interactions. • Proposed blending of face-to-face tutoring with digital platforms such as Blackboard LMS could improve feedback and progress monitoring.	

Regularly review and adjust EdTech integration			• Lecturers should keep up with the latest trends and tools by regularly reviewing and adjusting to cater for students with diverse learning needs. • There is a need to integrate digital tools effectively through regular evaluations, adapt to instructional needs and improve student engagement. • Online quizzes and automated grading systems require regular reviews to provide timely and meaningful feedback and enhance their evaluation effectiveness. • Obtain student input to ensure digital resources meet their needs and are adjusted for accessibility and usability. • Break up tasks into group collaborations and conduct regular reviews to optimise the use of collaborative online tools.	• Conduct biweekly meetings to evaluate student progress and gather input on digital tools and teaching techniques, to make curriculum adjustments. • Use anonymous questionnaires and learning analytics to assess student experiences and proficiency with digital resources, to enable timely interventions. • Suggest pilot tests of new digital tools to identify and resolve issues before full implementation, to ensure smooth integration in the learning process.	

Considerations					
Provide training in digital literacy	- Integrating simulations and tools fosters interaction with advanced technologies and supports digital literacy. - Exposure to digital tools enhances technological proficiency and confidence and improves overall digital literacy. - Using digital tools improves technological skills and promotes digital literacy. - Encouraging students to use digital tools helps develop their literacy and technical capabilities. - Digital and online resources enhance understanding, thereby contributing to digital literacy through consistent engagement. - Students agree that available digital resources help develop essential technological and literacy skills.	- The balance between technology use and traditional methods can affect academic success, depending on students' technology skills (Section 2.4). - Alternating between technology and books reveals challenges for some students in adapting to technology use (Section 2.4). - Flexible learning approaches provide alternatives for students with limited technological competence, thereby promoting engagement (Section 2.4).	Address troubleshooting challenges by consistently enhancing lecturers' technological skills.	- Despite being part of Generation Z, students need more expected digital skills; they need time to focus on developing basic digital literacy. - Limited proficiency in EdTech tools caused reluctance and wasted time on basic functions, mainly as tasks grew more complex. - While autonomy promotes self-directed learning and accountability, some students need help to adapt to a digitally integrated environment.	

Integrate content-specific tools	• Some participants expressed that digital and online tools were underutilised in previous educational settings, indicating room for improvement. • Suggestions include better utilisation of digital applications and online resources to enhance teaching and learning at the higher education level.	• EdTech tools facilitate learning experiences and support understanding in various contexts, though specific examples were not explicitly stated. • Tools for online assessments and test-related resources played a crucial role in evaluation and learning.	• Programmes such as AutoCAD, OnShape and ArchiCAD are used for teaching engineering and design-related subjects, thereby supporting practical and technical learning. • Integrate tools into teaching practices, though specific tools were not explicitly mentioned. • Technology enhances teaching and learning experiences, though specific tools were not mentioned.	• In Week 10, tools such as OnShape and CAD systems were used for technical drawings, orthographic designs and pictorial tasks. • The PAT evaluated proficiency in CAD management, technical drawing and EGD-specific design procedures. • Blackboard and QR code systems facilitated interactive engagement with assignments and enhanced collaboration. • Mobile devices were used to scan and upload assignments, and increased familiarity with content-specific technology. • Students struggled to master CAD tools such as OnShape and adapting to content-specific tasks, due to limited prior exposure. • Outdated institutional infrastructure, including slow desktops and Wi-Fi, disrupted the effective use of subject-specific tools.	

Pedagogical knowledge					
Guidelines					
Integrate blended learning models	Students preferred combining face-to-face and online methods and highlighted the benefits of flexibility and engagement in education.	- Responses emphasised the importance of effectively combining online and in-person methods to enhance engagement and provide better support. - In EGD, certain topics require online lectures or resources to complement in-person learning because of the practical nature of the subject.	- Discussed the integration of digital tools such as 3D modelling and simulations with hands-on activities to foster experiential and project-based learning. - Incorporate EGD online platforms such as Blackboard and OnShape alongside traditional methods for a dynamic blended learning experience. - Use tools such as OnShape and AutoCAD to enable a blend of in-class instruction and online resources to align with learning goals. - Encourage integrating digital tools into lesson planning to support blended approaches, thereby meeting diverse learning needs effectively (Section 5.3.4).	- Combine technology with conventional teaching to create a comprehensive educational experience. - Using face-to-face lessons, tutorials and online resources ensures active engagement and schedule adherence. - Integrating digital and traditional methods facilitates timely submission and feedback and enhances education results.	
Encourage active and collaborative learning	Use collaborative tools for group projects and team-based learning to foster engagement and teamwork among	Appreciation for laptops and digital tools emphasises the value of integrating collaborative tools and	Digital tools such as OnShape and AutoCAD are recommended to engage students by	Students used PowerPoint for assignments, with rubrics and comments on Blackboard	

	classmates and lecturers. • There is a need for interactive learning tools to support student collaboration and encourage active participation. • Encourage peer-based learning, where students collaborate to explore and understand new digital tools effectively. • Identified online collaborative tools, interactive simulations and adaptive learning platforms as effective strategies to promote active and collaborative learning through digital resources.	group activities to enhance motivation and engagement in learnin. • Tools such as OnShape are acknowledged for their interactive and collaborative features, such as supporting teamwork and active learning and making online assessments more engaging and dynamic.	enabling them to design and simulate real-world tasks. • Emphasised best practices for integrating collaborative tools in instructional design and utilising platforms such as Blackboard and shared CAD tools to facilitate group projects. • Suggested using 3D modelling and project-based activities to engage students in active, hands-on learning. • Highlighted simulations and digital tools as critical for fostering active problem-solving, critical thinking and collaborative learning through interactive platforms. • Recommended digital tools for structured, team-based tasks to ensure all students contribute meaningfully. • Encouraged breaking tasks up into smaller group assignments to foster teamwork and	fostering collaborative improvement. QR code-based attendance included reflection questions to enhance engagement. • Week 6 encouraged independent use of digital tools and peer collaboration, thereby combining traditional and digital methods to support teamwork. • Platforms such as OnShape, AI-powered notes and Blackboard Collaborate supported both individual and group tasks. Feedback systems such as Feedback Fruits emphasise active peer learning. • Text, voice and video tools facilitate work with experts and peers and promote higher-order collaborative tasks and advanced EdTech-driven active learning.	

			communication skills via online resources.		
Provide consistent feedback and support		• There is a need for regular and detailed feedback on students' use of interactive tools, which emphasises consistent support to improve their learning experience. • Gather continuous feedback to enhance the institution's technical support and ensure that both students and lecturers receive adequate assistance with EdTech tools.	• Use platforms such as Blackboard for structured updates and clear instructions to ensure consistent progress monitoring and feedback. • Use online tools for automated grading, quizzes and surveys to provide timely and meaningful feedback to students. • Automated tools are useful for frequent, time-saving evaluations without compromising feedback quality. • Regularly elicit student feedback to ensure digital tools are accessible and effective and support continuous improvement. • There is a need for structured group tasks with continuous support and monitoring to ensure active engagement and consistent guidance. • Use digital platforms such as Blackboard and grading rubrics to	• Weekly updates, assignment evaluations and structured Blackboard announcements keep students informed and supported in their tasks. • Detailed feedback included digital rubrics and annotated PDFs, which offered specific performance insights. Post-assignment memos provided additional clarity. • Weekly Blackboard updates, real-time QR attendance tracking and regular guidance ensured consistent monitoring and feedback. • Blackboard monitoring tools tracked assignments, participation and task completion and were complemented by weekly updates and progress guidance. • Feedback and reflection sessions helped students assess their understanding, with	

			deliver detailed feedback that addresses diverse learning needs effectively.	anonymous surveys addressing concerns promptly.	
Considerations					
Balance digital and hands-on learning	• LMS and online courses are incorporated into the learning process to provide a balance between digital and face-to-face teaching methods. • PowerPoint and other digital tools are used alongside hands-on approaches to enhance the learning experience. • Balance use of smartphones and other devices in class to integrate technology with traditional, hands-on teaching strategies.	• Online assignments demonstrate a balanced distribution of digital learning and traditional hands-on approaches. • Better integrate explanatory videos and online resources with hands-on or face-to-face teaching practices to enhance understanding. • Adopt a blended format for future courses by combining online and face-to-face lessons to ensure a balanced and effective learning experience.	• Highlights demonstrating software usage and integrating hands-on methods to create a balance between digital tools and practical learning. • Combines peer assessments, teacher feedback and digital tools to create a well-rounded learning environment. • Focuses on utilising knowledge of digital tools to complement and support hands-on teaching strategies.	• Blackboard facilitated both online and face-to-face sessions, with QR codes and real-time tracking merging traditional and digital attendance systems. • Students combined manual and digital techniques by alternating between in-person activities and independent work using resources such as videos and quizzes. • Reflection sessions confirmed the effectiveness of blending in-person and online learning but highlighted challenges such as digital literacy gaps and outdated resources. • Platforms such as Blackboard Collaborate and peer reviews supported teamwork, with tutorials integrating	

				hands-on and digital skills development. • Balance individual and group work in modules and upgrade infrastructure for better digital integration.	
Foster a blended learning environment		• Students develop strategies to effectively use both face-to-face and digital tools to reinforce the value of a blended learning approach. • Most students indicated a preference for hybrid learning environments that combine face-to-face instruction with online components to achieve optimal learning.	• Lectures and discussions combine traditional teaching methods with digital tools to establish a blended learning approach. This hybrid model integrates face-to-face interactions with online components to enhance student engagement and learning outcomes.	• Blackboard was central to the blended approach and supporting online assignments, announcements and discussions while complementing in-class teaching. • Students accessed materials, uploaded assignments and engaged in discussions online, which enhanced face-to-face sessions. • Lessons alternated between in-person instruction and independent digital tasks. • Weekly activities blended traditional tools (e.g., pencil drawing) with digital applications such as OnShape and TurboCAD. • Weekly schedules included specific	

				goals, tasks for in-class sessions and online resources such as presentations, videos and quizzes. • Real-time feedback mechanisms such as QR code attendance and Blackboard performance tracking ensured smooth integration. • Rubrics and detailed feedback complemented in-class evaluations for online submissions. • Blackboard Collaborate facilitated group projects, discussions and peer reviews and promoted online and offline collaboration. • Develop balanced modules that emphasise both hands-on and digital tasks.	
Encourage collaborative learning		• LMS platforms facilitate online collaborative learning and enable students to participate in group activities and virtual teamwork.	• Software such as OnShape enables real-time teamwork on design projects and supports interactive and cooperative learning. • Modern communication tools	• Limited collaboration using basic digital tools such as email. • Actively encourage collaborative learning using EdTech. • Students selected teamwork tools and engaged in activities	

		Students expressed a preference for collaborative environments in which tools effectively support group projects and peer learning.	improve group-based problem-solving and facilitating effective collaboration.	that had societal relevance. - Peer learning was emphasised during independent study. - Tools such as Blackboard Collaborate enabled structured group projects and peer teamwork. - Digital tools such as interactive e-documents and QR codes facilitated cooperation. - Organise interdisciplinary projects and hackathons to foster cross-disciplinary collaboration.	
Enhance personalised learning paths	Students prefer self-paced and individualised study environments, which highlights the importance of tailored approaches to improving understanding and engagement.	Students emphasised the use of tools such as explanatory videos, which enabled self-paced and individualised learning and supported a personalised approach to learning and teaching.	- Strategies should focus on designing tasks that meet individual learning needs and encourage independent thinking. - Self-paced learning with 3D modelling tools enhances visualisation skills, particularly in engineering and design topics. - Individual assessments are built on personal progress and supported by	- With limited personalisation, students passively consume content via Blackboard and videos. - Weekly feedback guided progress, but individualised approaches were minimal. - Students started selecting tools and resources independently for task completion.	

			teacher feedback and peer reviews. • Experiential and personalised learning environments foster deeper engagement and understanding.	• Students chose digital tools such as OnShape and TurboCAD based on their learning preferences. • Interactive e-documents and AI tools allowed self-paced exploration. • Blackboard monitoring enabled targeted interventions based on individual progress. • Highly self-directed learning emerged, with students selecting advanced tools for PATs. • Comprehensive digital resources supported customised learning paths. • Detailed rubrics and memos provided individualised feedback to enhance understanding of performance. • Limited digital literacy hindered effective personalisation. • Varied access to personal laptops and reliable infrastructure affected customisation. • Offer diverse resources	

				accommodate different learning preferences and goals.	
Expert panel					
					• Reference to and applicability of the concept Generation Z in the South African higher education landscape. • Limitation of the study with regard to the small sample size and the case study methodology. • The applicability of the 10-week intervention for other South African higher education institutions with special reference to the EGD module situated in engineering faculties where this module usually has a large enrolment.

In summary, the triangulated findings emphasise the critical importance of integrating educational technology effectively in the first-year EGD module. Addressing gaps in digital infrastructure, expanding access to resources and providing robust technical support are vital to enhancing equitable learning opportunities. Furthermore, comprehensive digital literacy training for students and educators remains a cornerstone for adapting to evolving EdTech tools. The balance between hands-on and digital learning approaches, complemented by blended learning models, fosters an interactive and engaging environment. Regular evaluation of EdTech practices, coupled with structured feedback mechanisms, ensures continuous improvement and alignment with educational objectives. Ultimately, the study highlights the necessity of a holistic strategy that combines personalised learning pathways, collaborative tools and content-specific applications to meet diverse student needs effectively.

6.7 CONCLUSION

In conclusion, Chapter 6 explained the important insights gained from the data analysis and discussions surrounding the integration of EdTech in a first-year EGD module for student teachers through the theoretical lens of TPACK. The findings emphasise the pivotal role of EdTech in enhancing student engagement and improving learning outcomes. However, the successful implementation of this framework necessitates addressing challenges related to digital literacy, resource accessibility and the need for adaptive instructional design (see Section 3.3). This chapter also highlighted the importance of aligning technological tools with education objectives to create a cohesive integration of online and in-person learning experiences (see Section 4.2.4) and achieve a more effective Hyflex teaching and learning environment. Additionally, the chapter suggested that future implementations call for a more organised professional development framework for educators (see Section 7.4) that focuses on the proficient use of educational technology in Hyflex environments.

Chapter 7 discussed the conclusions drawn from this research (see Section 7.3), including key lessons learned, and address limitations of the study (see Section 7.7). It will make suggestions for future research into implementing EdTech in Hyflex teaching and learning approaches to EGD (see Section 7.8).

CHAPTER 7

CONCLUSIONS, PROPOSED GUIDELINES AND CONTRIBUTION TO KNOWLEDGE

7.1 INTRODUCTION

This chapter situates the research results in the broader higher education context. It reflects on the implications of both methodological (theoretical) and substantive (practical) findings related to the main research question and five subsidiary questions (see Section 1.4) as explored throughout this thesis, with special reference to ways a technology education lecturer can employ a TPACK perspective (see Chapter 2) to effectively integrate EdTech in first-year EGD student teachers' online learning and teaching experiences. In this qualitative study that was complemented with quantitative elements, all possible measures were taken to ensure credibility, dependability, transferability, confirmability and reflexivity (see Chapter 5). All data was properly managed and stored and is available as an audit trail for any scrutiny or future use, such as secondary analysis.

This final chapter presents conclusions (see Section 7.3). Considerations were derived from the study to synthesise the findings of Chapter 6 that gave rise to the formulation of guidelines for future practice (see Section 7.5) for integrating EdTech in the online instruction of first-year EGD student teachers through the lens of the TPACK framework (also see Sections 2.3 and 6.1).

This chapter revisits and answers the main research questions (see Section 7.2). The discussion underscores the relevance of the TPACK framework for integrating EdTech in the teaching of first-year EGD student teachers by providing practical insights on utilising EdTech tools and highlighting the lessons learned throughout the study (see Section 7.6). The chapter concludes by proposing guidelines for future practice (see Section 7.5), making suggestions for future research (see Section 7.7) and evaluating the study limitations (see Section 7.8), thereby contributing to the body of knowledge in the field.

7.2 RESPONSIVENESS TO THE RESEARCH QUESTIONS

This study addressed the stipulated research questions (see Section 1.4.1) by focusing on the main research question: How can a technology education lecturer use a TPACK perspective to integrate EdTech for EGD first-year student teachers' online learning and teaching?

Five subsidiary research questions (see Section 1.4.2) were formulated from this main research question. The next sections (7.2.1–7.2.5) present the subsidiary questions. The answers that are provided to these questions are based on related critical debates in the literature, empirical research findings and data collected from EGD first-year student teachers and lecturers, which were validated by an expert panel (see Sections 5.9, 5.10 and 6.4).

7.2.1 How can integrating EdTech in first-year EGD online learning and teaching be conceptualised through a TPACK perspective?

The first subsidiary research question addresses the conceptualisation and value of TPACK when integrating EdTech in first-year EGD online learning and teaching through the TPACK framework by examining how the interplay of TK, PK and CK can enhance education outcomes by creating a HyFlex teaching and learning environment. Discussions on significant literature perspectives of the three critical knowledge areas of TPACK (including its conceptualisation as an interconnected schema working in a cohesive way to enhance learning in teaching outcomes) can be found in Sections 2.3.1, 2.3.2 and 2.3.3.

It emerged that CK refers to subject-specific expertise, which is enhanced by using digital tools (see Section 2.3.1). PK involves adapting effective teaching strategies to incorporate technology use (see Section 2.3.2). Consequently, TK focuses on understanding digital tools such as CAD software and the Blackboard learning platform (see Section 2.3.3).

Data collected with the two first-year EGD student teacher questionnaires (see Appendices D and E) that were administered before and after the 10-week intervention, respectively, expose the importance of integrating CK, PK and TK for effective teaching in EGD. The findings highlight that CAD software (AutoCAD, OnShape) and Blackboard are highly effective at enhancing student comprehension

of complex concepts such as orthographic projections and 3D modelling and fostering conceptual and practical skills (see Section 6.3.3.2). Effective teaching strategies that incorporate blended learning (HyFlex) models, video tutorials and real-time feedback through Blackboard significantly improved student engagement and understanding (Section 6.3.2.3). However, some students struggled to master the complexity of these digital tools, which highlights gaps in technology knowledge (see Section 6.3.2.2).

The findings indicate that integrating CK, PK and TK is essential for dynamic and student-centred teaching. Teaching strategies must adapt to include tools such as Blackboard and CAD software, which enhance active learning and interactivity and ensure students can grasp complex concepts more effectively (see Sections 6.3.3.2, 6.3.2.3). This implies that foundational digital literacy training is needed to address varied levels of technological proficiency among students to enable them to engage fully with digital tools such as CAD software and Blackboard (see Section 6.3.1.5). Furthermore, institutions should regularly update pedagogical strategies to incorporate emerging technologies, such as video resources and interactive simulations, while addressing infrastructure challenges, including improving access to reliable internet, updated devices and software, to ensure equitable engagement with EdTech tools (see Sections 6.3.2.3 and 6.3.1.3).

Discussions of additional literature perspectives on the value of TPACK for integrating EdTech in the first-year EGD higher education context can be found in Section 2.4. First, the literature review underscores that integrating digital tools into EGD teaching through the TPACK framework enables educators to enhance student comprehension of essential EGD concepts such as technical drawing and spatial visualisation (see Section 2.4.1). By applying TPACK, educators can thoughtfully select and apply technology to support specific content while aligning with best teaching practices. This approach ensures that technology integration is meaningful and purposeful rather than a superficial addition; this approach can ultimately result in improved learning outcomes. Chapter 2 also provided a balanced evaluation of the advantages and challenges of implementing TPACK in EGD teaching (see Section 2.4). While TPACK fosters innovation and student engagement through digital tools (see Section 3.3), it highlights the need to address varied levels of digital literacy among students and teachers, in order to realise its potential (see Section 3.4) fully. Data collected from the two first-year EGD student teacher questionnaires (see Appendices D and E) that

were administered before and after the 10-week intervention, reveal the critical role of EdTech tools such as Blackboard, CAD software (AutoCAD, OnShape) and YouTube in enhancing student engagement and understanding of complex EGD concepts, including 3D modelling and engineering drawings. These tools were essential for communication, resource management and learning flexibility (see Section 6.3.1.1). The findings also report an increased preference for blended learning (HyFlex) by students after the intervention, with most students favouring a mix of in-person and digital approaches to meet their education needs (see Section 6.3.2.1). However, challenges such as digital literacy gaps, unreliable Wi-Fi and outdated hardware were significant impediments to students fully leveraging these tools (see Section 6.3.1.3).

The findings indicate that EdTech tools are pivotal for improving visualisation, comprehension and engagement in EGD, particularly for vision-heavy subjects. However, their effectiveness varies according to individual learning preferences and subject matter (see Sections 6.3.3.2 and 6.3.1.2). This implies that, to ensure equitable student engagement, institutions must address digital literacy gaps through foundational training on tools such as CAD and Blackboard (see Section 6.3.1.5). Infrastructure improvements, such as providing reliable Wi-Fi and updated hardware, are critical for overcoming technical barriers (see Section 6.3.1.3). Moreover, integrating personalised feedback and progress tracking in platforms such as Blackboard can significantly enhance student engagement and learning outcomes. At the same time, a balanced approach to combining EdTech with traditional methods is necessary to meet the practical requirements of EGD (see Sections 6.3.3.1 and 6.3.3.2).

In conclusion, Chapter 2 illustrated that TPACK could be an essential tool for conceptually and practically integrating technology in EGD education by balancing content and pedagogy to meet the evolving needs of modern, diverse learners (also linked to Chapter 3) and the demands of Education 4.0 (connects with Chapter 4).

7.2.2 How do diverse students' learning styles and instruction method preferences influence online learning and teaching?

The second subsidiary research question (see Section 1.4.2) enquired how digital technology (e.g., Education 4.0 as a response to 4IR) influences diverse students' learning styles and preferences for instruction methods in an online learning and

teaching environment. Student teachers are among the digital natives who are digitally proficient and demonstrate comfort with technology (see Chapter 3.). Discussions on these findings can be found in Section 6.2.3. It emerged that eight EGD participants spent between 6 and 10 hours a week using EdTech resources. The empirical data (see Section 6.3.1.2) show that students use platforms such as Blackboard and CAD software extensively, and that multimedia resources, mainly video tutorials, aid their understanding of complex concepts. This reliance on these tools supports the theoretical insights presented in Chapter 3.

In response to an investigation into learning style preferences and multimodal approaches, it became evident that the characteristics and online attributes of student teachers relate to unique learning preferences (see Section 3.3), which is emphasised by their inclination to prefer multimodal strategies that combine visual, auditory and interactive content. Additionally, these students favour self-paced and flexible learning environments in which they can choose their own pace and methods. These findings were discussed in Chapter 6 (see Section 6.3.2.1). First-year EGD students supported these preferences, as they frequently utilised resources such as YouTube for visual explanations and CAD tutorials for hands-on practise. The qualitative methodology enabled me to understand that an EGD lecturer, when choosing EdTech to support the independent application of these tools, particularly for visual and complex subjects such as EGD, needs to balance student teachers' characteristics with online attributes. This connection suggests that the multimodal and flexible learning approaches outlined in Chapter 3 and implemented during the intervention effectively aligned with student preferences for varied and adaptable learning formats. Chapter 3 also emphasised that these students excel in flexible, student-centred environments where they can use various digital tools for individual and collaborative learning. The findings are that first-year EGD participants regarded various devices participants owned (smartphones, tablets/iPads, laptops and desktop computers) as valuable for their learning. The majority of participants ($n = 12$) identified laptops and desktop computers as being the most valuable devices in a learning environment. The participants ($n = 12$) identified Blackboard, the LMS in use at the University of the Free State, as pivotal for managing their own coursework and accessing academic resources. Blackboard were also useful for communicating with lecturers and other students. These positive experiences of first-year student EGD teachers confirmed the

essential function of Blackboard in promoting organised, interactive learning environments. The significance of the findings is that interactive and structured digital tools are vital for enhancing student engagement and for assisting participants to achieve their learning outcomes. Aspects related to PK, as evident in the themes of the Learning environment and resources and Pedagogical strategies, were reinforced by the participants' (n = 14) positive experiences of technology, which assisted them in developing their organisational skills and promoted interactive learning.

The PK theme of Digital tools aligns with the preferences of Generation Z for diverse sensory, visual and multimedia learning (Pandya, 2023). The need for meaningful guidance and continuous support by lecturers when new technologies are introduced to students as teaching strategies was identified. This support and guidance would be helpful for students who feel overwhelmed or discouraged when they are first introduced to new digital resources. However, Chapter 3 also referred to challenges such as digital fatigue, differences in technological expertise and the need for improved institutional support to utilise EdTech fully. Chapter 6 (see Section 6.3.1.3) provides specific examples of these difficulties. Students reported experiencing problems related to slow or unreliable Wi-Fi and outdated computer lab equipment. The use of resource-intensive software such as CAD highlighted the need for better technology infrastructure and support, as emphasised in Chapter 3. The alignment between these sections indicates that, while student teachers typically adapt well to technology, technical barriers can significantly hinder their learning experiences. The challenges outlined in Chapter 6 underscore the importance of improving digital access and support mechanisms. As a participant reported, *Network problems were a big concern. Slow or unstable Wi-Fi made it difficult to complete and submit assignments.* This feedback confirms the issues of digital access and fatigue discussed in Section 3.4. The discussion of the development of TK (see Section 3.4) refers to the importance of building up TK as part of the TPACK framework for student teachers. While these students are generally tech savvy, they still require guidance to effectively use specialised education tools such as CAD software. Chapter 6 (see Section 6.3.1.4) also provided evidence of a confirmed improvement in students' digital skills, particularly with complex tools such as CAD. Before the 10-week intervention, students experienced difficulties with these technologies but, after exposure, tutorials and peer support, their TK showed applicable growth. This

progression aligns with the need for structured development of TK, as highlighted in Chapter 3, to reinforce the value of the TPACK framework in supporting the effective use of digital tools. One student participant said, *The use of tutorials and YouTube videos helped me overcome challenges with the new CAD software*, which illustrates the development of digital competence discussed in Section 3.4.

In brief, the empirical findings provide applicable evidence to support the themes of digital proficiency, multimodal learning, student-centred approaches and the need for enhanced digital literacy and infrastructure. These connections confirm the importance of understanding the unique characteristics of student teachers and their online attributes when designing effective online learning environments, which could, ultimately, lead to improved engagement and education outcomes.

7.2.3 What are the critical trends in Education 4.0 for applying EdTech in EGD online learning and teaching?

The third subsidiary research question (see Section 1.4.2), on the diverse trends and their educational implications in a digital age characterised by the evolving landscape of Education 4.0, focuses on integrating advanced technologies in online learning and teaching and is reported on in Chapter 4. A significant trend is the integration of EdTech to support personalised and adaptive learning (see Section 4.2.1). Adaptive learning systems enable customised pathways that are based on individual progress, strengths and needs, promotes engagement and improves learning outcomes in online environments. Structured digital tools, such as LMS platforms and online assessments, enhance student engagement and learning outcomes. These tools provide a clear framework for organising coursework and supporting effective communication. This finding is underscored by the frequent use of EdTech tools such as Blackboard and YouTube (see Section 6.3.1.4), which allowed students to learn at their own pace and helped address their individual needs. Additionally, blended and hybrid learning models (see Section 4.2.2) that combine in-person and online education to provide essential flexibility, a key trend in Education 4.0, were emphasised. This is crucial for the generation of students currently at university, who value the autonomy to decide when, where and how they learn. Education 4.0 supports diverse learning options by allowing students to choose between on-site, synchronous and asynchronous learning formats, to suit individual preferences. For

example, the statement that *I used YouTube videos at my own pace for exam preparation* reflects the flexibility and self-directed learning preferences discussed in Chapter 4. The findings (see Section 6.3.2.1) confirm that students benefited from a blended learning approach. Tools such as WhatsApp groups and Blackboard were used effectively for both on-campus and remote study to offer the flexibility students needed. Many students preferred using mobile-friendly platforms to help them balance coursework with other responsibilities. Additionally, growth in TK (see Section 4.3.1) indicates the need for both students and educators to use EdTech, such as LMSs and CAD software, effectively. The empirical findings (see Section 6.3.1.1) demonstrate an applicable growth in students' TK throughout the intervention. While many students initially lacked familiarity with tools such as CAD software, instructional videos and tutorials helped them gain confidence and competence in using these technologies. As one student said, *We had to adapt to using digital resources after high school*, which refers to the development of new technological skills.

However, the literature review in Chapter 4 reports on potential barriers to effective implementation of EdTech (see Section 4.2.5). Issues such as unstable internet connectivity, outdated hardware and the digital divide were exposed as challenges that limit student access to EdTech and hinder their ability to engage fully with digital learning environments. The feedback, *Network problems made it difficult to complete and submit assignments*, directly mirrors the issues identified in Chapter 4 (see Section 6.3.1.3). Students frequently reported technical issues such as slow Wi-Fi and inadequate hardware in computer labs. These challenges were particularly problematic when they used resource-intensive software such as CAD. Furthermore, a key trend in Education 4.0 is the shift towards student-centred learning and engagement (see Section 4.3), which gives students greater control over their learning process. Digital platforms facilitate active participation, collaborative learning and 24/7 access to resources, thereby empowering students to take charge of their higher education journey. The strong student engagement through self-directed tools such as YouTube and collaborative platforms such as WhatsApp groups is described by the empirical findings (see Section 6.3.2.2). These resources supported students' preferences for flexible, interactive learning and aligned with a student-centred approach.

7.2.4 How can EdTech in online learning and teaching of first-year EGD student teachers (after being introduced) meet the needs and Education 4.0?

The fourth subsidiary research question (see Section 1.4.2) focuses on the perceptions and experiences of first-year EGD students after the 10-week intervention during which EdTech was integrated in online learning and teaching. Data were collected from two first-year EGD student questionnaires (see Appendices D and E) and the self-reflections of two lecturers – the one who presented the first-year module and the one responsible for the second-year module). Discussions on additional empirical data and findings are provided in Chapter 6. By analysing findings through the three TPACK components, TK, PK and CK, the following insights emerged.

- Regarding **TK** (see Section 6.3.1), EdTech tools such as Blackboard, YouTube and CAD software (AutoCAD, OnShape) appeared to be essential for bridging the gap between theoretical and practical learning needs. These tools facilitated self-paced learning and digital skill development and are aligned with the focus on real-world applications of Education 4.0. Students displayed increasing confidence about using these technologies, especially for digital drawing tasks.
- For **PK**, as discussed in Section 6.3.2, blended learning and interactive methods were found to be effective for engaging student teachers who favour digital, flexible environments. EdTech was appreciated for simplifying complex topics and increasing engagement. However, challenges such as gaps in digital literacy and unequal access were reported, which indicates a need for balanced guidance and integration with traditional methods.
- Regarding **CK** (see Section 6.3.3), EdTech tools such as CAD software enhanced comprehension of complex EGD concepts through visual aids and simulations, by making abstract ideas more accessible. However, hands-on learning was still deemed necessary, which suggests that, while EdTech strengthens understanding, it should supplement rather than replace traditional learning methods.

Integration with Education 4.0 (see Chapter 6) involves advocating for student-centred, flexible learning and digital competency development. In this study, EdTech tools enabled personalised learning, boosted engagement and prepared students for digital work environments, thereby supporting modern educational demands.

7.2.5 What guidelines can be proposed for integrating EdTech in the online learning and teaching of first-year EGD student teachers through a TPACK lens?

The fifth subsidiary research question (see Section 1.4.2.5) proposes guidelines (see Section 7.5) for first-year EGD lecturers, based on the TPACK framework (see Chapter 2). The guidelines offers a valuable strategy for lecturers to incorporate EdTech in their classrooms while considering the relevant learning and teaching pedagogies, as well as the EGD CK, for first-year EGD student teachers. All three knowledge domains of TPACK remain crucial in highlighting the proposed guidelines. For example, lecturers integrating TK in their lectures encourage students to engage interactively using structured tools, which enhances student engagement and learning outcomes. The findings indicate that, although digital resources play a vital role in learning for student teachers, an opportunity exists to enhance or complement fewer interactive tools, thereby enabling students to maximise the advantages of these technologies. The EGD student participants demonstrated some applicable acquisition of 4IR skills by using, interacting with and providing solutions for a wide range of digital resources, including CAD programmes. This finding affirms the need for lecturers to teach students about the TK and the skills they need, so that implementation and execution of EdTech by the students can be effective. Lecturers need to be aware that these practical and interactive subjects may demand more physical, interactive engagement, in both virtual and physical learning environments that use specialised digital tools. The use of PK by lecturers has an impactful result on how students engage and participate in lessons. The five characteristics of meaningful learning – active learning, collaborative learning, constructive learning, authentic learning and goal-directed learning (Shaw et al., 2018) – align with the approach of Valverde-Berrocoso et al. (2021), of collaboration, metacognitive reflection and analysis, mixed-learning, both in-class and out-of-class diverse digital resources, modelling-based learning, where the lecturer models being a tutor or mentor when

engaging with students, and authentic learning as real-life situations. These teaching strategies meet and address the needs of the student teacher participants to succeed in the EGD learning environment. The HyFlex teaching strategy in an authentic learning environment should make it possible for the EGDC1614 students to access content whenever it suits them. They could also submit their tasks on a flexible timeframe, when it suited them, within reason and aligned with the assessment plan of the academic calendar. They were able to collaborate on the Blackboard digital platform with both the lecturer and fellow students. This was received positively by participants. Additionally, the exploration and integration of Education 4.0 to transform education in the future through cutting-edge technology and advocating for student-centred, flexible learning and digital competency development, demonstrates the alignment with TPK. A suggestion for lecturers is that, when they teach practical subjects, they need to consider the integration of teaching strategies with technologies, which require the knowledge to implement the relevant digital resources. Furthermore, the CK of this EGD aligns closely with knowledge and use of digital tools. These EGD tools, such as the CAD software, enhanced student comprehension and understanding skills when they had to address complex EGD concepts. The hands-on learning was supplemented and reinforced by digital tools, rather than by replacing it. The digital tools assisted in making abstract ideas more accessible. By applying TPACK holistically, lecturers can thoughtfully select and apply technology to support specific content while aligning with best teaching practices. This proposed guideline (see Section 7.5) for integrating EdTech in the online learning and teaching of first-year EGD student teachers through a TPACK lens ensures technology integration is meaningful and purposeful rather than a superficial addition, and thereby ultimately positively benefits students' learning.

7.3 CONCLUSIONS DRAWN FROM THIS STUDY

The conclusions derived from this study offer significant insights into integrating EdTech in the realm of first-year EGD modules for student teachers. The findings address the essential elements of the TPACK framework, namely TK (see Section 7.3.1), PK (see Section 7.3.2) and CK (see Section 7.3.3), thereby providing a nuanced understanding of how digital tools and strategies affect online learning and teaching processes in EGD. This investigation emphasises the practical application of

EdTech to enhance student engagement and learning outcomes, while identifying the challenges and requisite supports needed for successful implementation in a HyFlex learning context.

7.3.1 Aspects related to the TK domain

To achieve effective technology integration, barriers such as varied levels of digital literacy and access to the necessary digital tools and a stable internet connection must be addressed (see Section 6.3.1.3). Also, tailored support is essential (see Section 6.3.1.4) for maximising the benefits of these technological resources and comprises digital literacy training and structured guidance on utilising complex software such as AutoCAD and OnShape (see Section 6.3.2.3).

7.3.2 Related PK domain aspects

First, the research illustrates that combining EdTech with suitable pedagogical strategies fosters a dynamic, student-centred learning environment (see Section 6.3.2.3). Second, blended learning models, which harmonise digital tools with face-to-face interaction, are vital for accommodating the diverse learning styles and instruction mode preferences of first-year EGD student teachers (see Sections 6.3.2.1 and 6.3.2.4). Third, first-year EGD student teacher participants preferred interactive and multimedia resources that facilitated their understanding of complex concepts. At the same time, continuous guidance and structured feedback were identified as crucial components needed for their success (see Sections 6.3.1.5, 6.3.2.2 and 6.3.2.4).

7.3.3 Relevant CK domain aspects

The findings indicate that EdTech tools, including CAD software and simulations, provide confirmable support for first-year student teachers regarding both understanding and applying complex concepts in EGD (see Sections 6.3.1.1 and 6.3.2.2). However, it is essential to recognise that, while digital tools enhance content delivery, hands-on, practical experiences remain critical for mastering EGD content (see Sections 6.3.3.2 and 6.3.3.3).

The study suggests that content-specific training and personalised learning pathways are needed to empower students to effectively apply digital tools in alignment with the subject-specific requirements of EGD (see Sections 6.3.1.4, 6.3.2.3 and 6.3.3.3).

7.4 PROPOSED CONTRIBUTION TO INTEGRATING EDUCATIONAL TECHNOLOGY IN EGD THROUGH TPACK

The TPACK framework that was adopted and tailored for the effective integration of EdTech in the teaching and learning of EGD is illustrated in Figure 7.1. This revised framework emphasises the interconnected nature of TK, PK and CK, which are all essential for addressing the diverse needs of EGD students in a digital learning environment. The framework also lists key strategies for enhancing the digital competencies of educators and fostering student engagement through interactive tools, personalised learning pathways and blended learning models. By aligning pedagogical approaches with technological advancements, the revised framework aims to support a dynamic, student-centred learning experience that prepares learners for the challenges of the evolving digital landscape in the field of EGD.

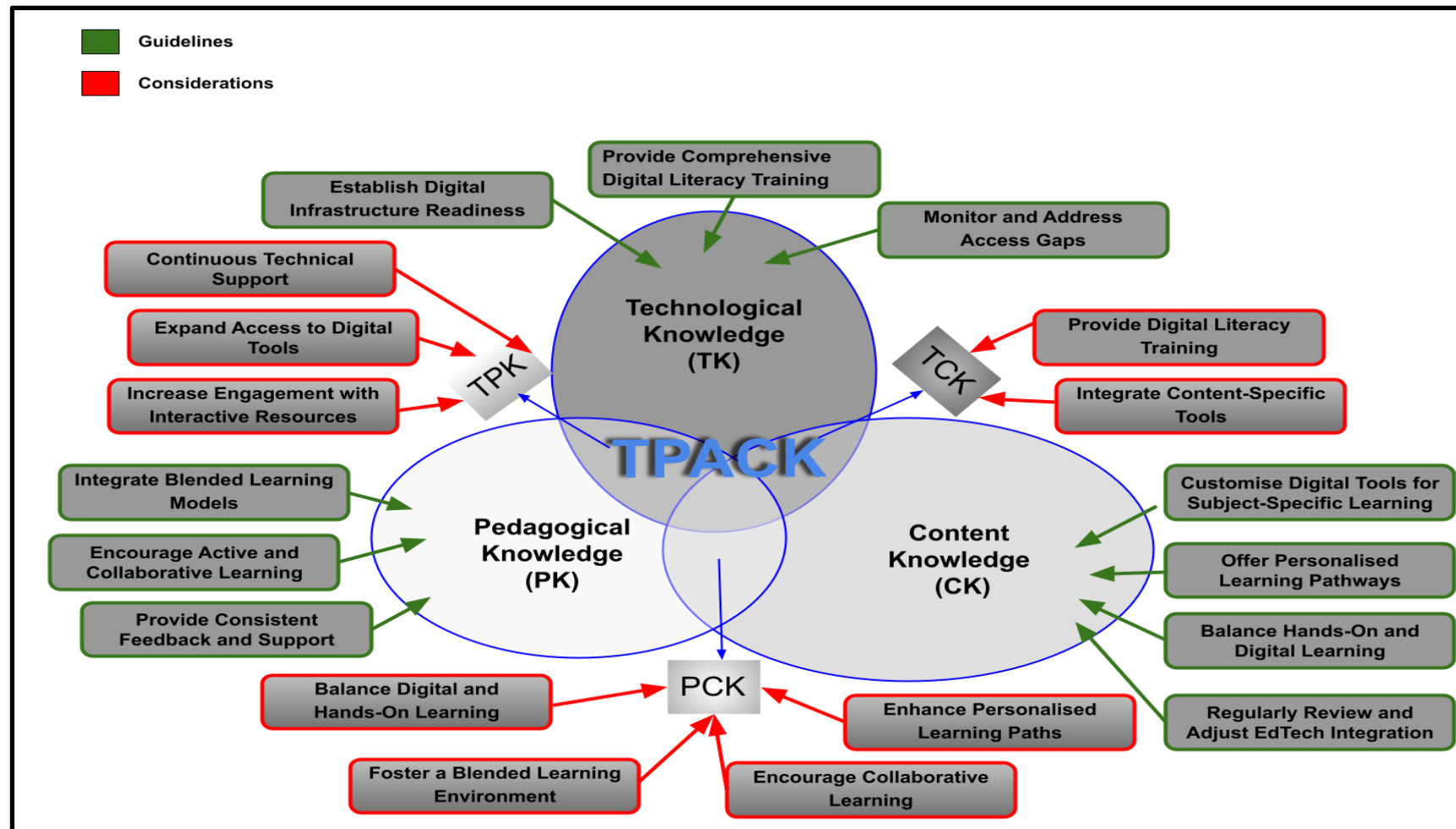


Figure 7.1: TPACK-based EdTech integration framework for teaching and learning in EGD in a HyFlex environment
(Mishra et al, 2009)

From Figure 7.1 it is evident that, to improve the education experience and prepare students with essential tools for success in a digital learning environment, it is essential to offer deliberate and focused considerations across the domains of TK, PK and CK. This section will present applicable considerations for incorporation to enhance the integration of EdTech in technology education, particularly EGD. The focus is on promoting the utilisation of underused digital tools, improving the usability of current platforms and offering tailored support for students as they navigate intricate technologies.

7.4.1 TK considerations

7.4.1.1 *Expand the use of underutilised tools*

- Ensure students have equitable access to the necessary software, such as CAD tools (AutoCAD, OnShape), and provide licensing options or institution-wide subscriptions for ease of use (see Section 6.3.2.1).
- Improve the institution's infrastructure, particularly internet access and computer hardware, to support the seamless use of digital tools (see Section 6.3.2.1).

7.4.1.2 *Provide digital literacy training*

- Offer digital literacy workshops or bootcamps at the start of the academic year that cover essential software such as Blackboard, CAD tools and online collaboration platforms (see Section 6.3.1.4).
- Introduce peer-led mentorship programmes, through which students who are proficient in digital tools can help others in a structured learning environment (see Section 6.3.1.4).

7.4.1.3 *Continuous technical support*

- Establish dedicated technical support teams or digital helpdesks to assist students and staff to navigate and troubleshoot digital tools (see Section 6.3.1.5).
- Develop easy-to-follow, step-by-step guides for software and platform usage to reduce confusion and frustration (see Section 6.3.1.5).

7.4.2 PK considerations

7.4.2.1 *Foster a blended learning environment*

- Implement a blended learning model by combining face-to-face teaching with digital learning to cater for various student preferences and to balance practical and theoretical learning (see Section 6.3.2.1).
- Design assignments that encourage the use of digital tools (e.g., CAD software) and hands-on learning experiences (e.g., physical models) to ensure a comprehensive learning approach (see Section 6.3.2.1).

7.4.2.2 *Increase engagement with interactive resources*

- Integrate more interactive content, such as multimedia tutorials, simulations and videos, into course materials to enhance student engagement and comprehension (see Section 6.3.2.2).
- Use student feedback to continuously improve and personalise digital content, ensuring it aligns with the learning objectives of the course (see Section 6.3.2.2).

7.4.2.3 *Encourage collaborative learning*

- Create structured group activities and projects that utilise online collaboration tools, such as shared platforms for team-based assignments or group discussions (see Section 6.3.2.3).
- Provide guidelines for using collaborative platforms effectively, by ensuring students understand how to use them productively without distractions (see Section 6.3.2.3).

7.4.3 CK considerations

7.4.3.1 *Enhance personalised learning pathways*

- Offer personalised learning pathways by incorporating adaptive learning technologies that allow students to progress at their own pace; focus on areas where they need the most support (see Section 6.3.3.1).
- Utilise quizzes, simulations and automated feedback systems to help students track their progress and focus on key content areas (see Section 6.3.3.1).

7.4.3.2 *Integrate content-specific tools*

- Ensure digital tools align closely with the content being taught. For EGD, prioritise visual tools and simulations that promote the practical understanding of concepts such as technical drawing and design processes (see Section 6.3.3.2).
- Provide training sessions tailored to the specific demands of the content and ensure students know how to apply tools effectively in their subject (see Section 6.3.3.2).

7.4.3.3 *Balance digital and hands-on learning*

- Continue incorporating hands-on, face-to-face sessions alongside digital tools, especially for subjects such as EGD, where practical experience is crucial (see Sections 6.3.2.1 and 6.3.2.2).
- Structure assessments to evaluate both digital proficiency and the ability to apply theoretical knowledge in practical, real-world scenarios (see Sections 6.3.2.1 and 6.3.2.2).

The proposed considerations offer a comprehensive strategy to enhance the digital learning environment for students. By expanding the use of underutilised tools, addressing usability issues and providing tailored support for complex technologies, institutions can foster innovation and ensure more effective engagement with digital resources.

7.5 GUIDELINES FOR TECHNOLOGY EDUCATION LECTURERS TO USE A PERSPECTIVE OF TPACK TO INTEGRATE EDTECH IN THE ONLINE TEACHING AND LEARNING OF EGD FIRST-YEAR STUDENTS

The following guidelines provide actionable steps for integrating EdTech into the online learning and teaching process of EGD, by focusing on the core components of TK, PK and CK. These guidelines are designed to enhance digital infrastructure, promote effective teaching strategies and align technology use with subject-specific learning outcomes. By addressing digital literacy, supporting blended learning models and tailoring content delivery, the guidelines aim to equip both students and educators with

the necessary skills and resources to optimise the use of EdTech in an inclusive and effective manner.

7.5.1 Technological knowledge

7.5.1.1 *Establish digital infrastructure readiness*

- Ensure that the hardware and software infrastructure (e.g., high-speed internet, updated computers and required software) of the institution is fully equipped to integrate digital tools seamlessly).
- Implement a regular review and upgrade cycle for digital infrastructure, by assessing current technological needs and identifying areas for improvement.

7.5.1.2 *Provide comprehensive digital literacy training*

- Introduce mandatory digital literacy workshops for both students and educators at the start of the semester to ensure proficiency in using key EdTech tools such as CAD software and Blackboard.
- Offer ongoing digital skills support through regular tutorials, webinars and peer-to-peer mentoring programmes throughout the academic year.
- Develop easy-to-use manuals, videos and FAQs (frequently asked questions) for troubleshooting common technical issues.

7.5.1.3 *Monitor and address access gaps*

- Conduct an initial assessment of students' access to digital tools, including hardware (e.g., laptops, tablets) and internet connectivity, to identify potential barriers.
- Create support mechanisms, such as loan programmes for devices or campus hotspots, to ensure equitable student access.

7.5.2 Pedagogical knowledge

7.5.2.1 *Integrate blended learning models*

- Design courses that balance face-to-face interaction with online components to ensure flexibility for students with different learning preferences.
- Structure the course so that digital activities (e.g., CAD exercises, online discussions) complement in-person sessions, thereby providing a cohesive learning experience.
- Train educators to adopt student-centred approaches using EdTech tools, by ensuring they can facilitate virtual and physical classroom environments effectively.

7.5.2.2 *Encourage active and collaborative learning*

- Develop clear guidelines for using collaborative tools (e.g., Google Docs, Blackboard Collaborate, Microsoft Teams) for team-based projects and peer feedback activities.
- Structure group projects that encourage peer-to-peer learning and require students to apply digital skills in collaborative settings.
- Incorporate interactive content such as videos, simulations and quizzes that align with course objectives, to enhance engagement.

7.5.2.3 *Provide consistent feedback and support*

- Establish a feedback mechanism through which students receive regular, constructive feedback on their digital work (e.g., CAD projects) to ensure continuous improvement.
- Set up communication channels through which students can seek support from educators, peers and tech support teams in a timely and structured manner.

7.5.3 Content knowledge

7.5.3.1 *Customise digital tools for subject-specific learning*

- Align the use of digital tools directly with the course content and ensure that software such as AutoCAD or OnShape is seamlessly integrated into the learning process for EGD.
- Create subject-specific tutorials and workshops that focus on the practical application of digital tools in the EGD curriculum.

7.5.3.2 *Offer personalised learning pathways*

- Implement adaptive learning technologies that allow students to move through the content at their own pace by focusing on areas where they need more practise or deeper understanding.
- Provide a variety of assessments that cater for different learning styles and instruction mode preferences, to ensure that both theoretical knowledge and practical skills are evaluated effectively.

7.5.3.3 *Balance hands-on and digital learning*

- Design assessments that require students to demonstrate proficiency in hands-on tasks (e.g., model building) and digital tasks (e.g., CAD design) to ensure a comprehensive learning approach.
- Maintain a balanced curriculum in which digital tools complement, rather than replace, traditional practical activities and allow students to develop a well-rounded skill set.

7.5.3.4 *Regularly review and adjust EdTech integration*

- Set up periodic evaluations to assess the effectiveness of the implemented EdTech tools for enhancing learning outcomes. Gather feedback from both students and educators on their experiences and challenges.
- Use data from student performance, engagement metrics and feedback to make iterative improvements to the EdTech integration strategy.
- Encourage educators to engage in reflection practices, by using feedback to adjust their teaching approaches and the integration of digital tools.

Additionally, for application of these guidelines, it is essential to consider who the students are and in what context (e.g., as highlighted in the expert panel [see Sections 5.9, 6.4 and 7.2]) the EGD module of the study is situated. In this case, it was a BEd programme that typically has small EGD classes (e.g., intervention is practical and applicable) but at other higher education institutions, the EGD module may fall under the Faculty of Engineering, which typically has large classes and applicability may require additional research.

7.6 LESSONS LEARNED THROUGH CRITICAL SELF-REFLECTION

As explained in Sections 2.4.3 and 5.3 and Figure 2.2, the implementation of EdTech in a first-year EGD module followed the five levels of the TIM (Shaw et al., 2018), with an in-depth analysis conducted over 10 weeks (see Section 5.5.1 and Table 5.2). Thorough systematic reflection on each level of Gibbs's six levels provided a structured approach to understanding and evaluating the implementation process (see Appendix F). This reflection highlights several key insights, which are organised into 10 distinct categories of lessons learned.

7.6.1 Digital literacy training

A key insight was that many students encountered challenges relating to foundational tasks, such as navigating Blackboard, creating illustrations in PowerPoint, scanning and uploading assignments and using CAD software such as OnShape (see Section 6.3.1.3). These difficulties with essential tools disrupted their workflow, caused dissatisfaction and delayed overall progress. Offering supplementary training or resources for these fundamental skills may improve students' digital proficiency and allow them to focus more effectively on complex tasks.

7.6.2 Technical infrastructure enhancements

Outdated computers and slow Wi-Fi were significant barriers that limited students' effective engagement with digital tools (see Section 6.3.1.3). This barrier resulted in frustration and delays in completing assignments, thereby impacting both productivity and learning outcomes. Upgrading technical infrastructure would enhance access to critical resources and improve students' academic experience.

7.6.3 Clear, structured support for digital tools

Students often felt overwhelmed by the range of digital tools they were expected to use, particularly in the absence of clear, step-by-step guidance (see Sections 6.3.1.4 and 6.3.1.5). This confusion initially hindered their ability to work independently, which highlights the need for structured support at the outset of the intervention, for example, practical tutorials, training videos or online consultation.

7.6.4 Enhanced integration of digital tools

Although various digital tools were introduced, students initially struggled to see their relevance and benefits. Some resisted tools such as OnShape and PowerPoint for drawing (see Section 6.3.2.2) because they did not immediately recognise their value. This underscores the need for clearer guidance on the practical applications of these tools to foster greater acceptance and usage.

7.6.5 Addressing student resistance to technology

Several students ($n = 5$) resisted digital tools, particularly at the start of the intervention (see 6.3.1.5). This resistance primarily stemmed from unfamiliarity and discomfort with new technologies.

7.6.6 Balanced learning approaches

While digital tools promoted independent learning, some students felt overwhelmed by the self-directed nature of assignments, especially students who were less familiar with the technology (see Sections 6.3.2.1 and 6.3.1.5). Others expressed a desire for more collaborative learning opportunities.

7.6.7 Enhancing feedback and monitoring systems

Continuous feedback was a positive aspect of the intervention; however, ensuring that feedback was consistently timely and that all students felt adequately monitored posed challenges (see Sections 6.3.1.6 and 6.3.2.3).

7.6.8 Technical contingency planning

Reliance on technology created issues when technical problems arose (e.g., slow Wi-Fi, malfunctioning equipment), which left students feeling frustrated and interrupting the learning process (see Section 6.3.1.3).

7.6.9 Access to ongoing professional development for educators

The lecturer played a crucial role in guiding students through their digital learning journey. Staying current with emerging educational technologies would allow the lecturer to continue providing effective support (see Section 6.3.1.6).

7.6.10 Fostering engagement with interactive digital resources

While students appreciated the interactive elements incorporated into the course, such as videos and multimedia, integrating more engaging digital content could enhance motivation further (see Section 6.3.2.2).

The discussion now moves on to the limitations of this research (see Section 7.7) and, thereafter, suggestions for future research (see Section 7.8).

7.7 LIMITATIONS OF THE STUDY

While this study offers valuable insights into integrating EdTech for student teachers in EGD, its findings are based on a single institutional case study (Cullen, 2021; Hodgins & O'Connor, 2021) at a South African university. This localised focus limits the generalisability of the results for other contexts or larger student groups – a common limitation in case study research, as discussed by Yin and Campbell (2018).

A notable limitation of the study is its small sample size, which was only 19 students who were enrolled for the EGD module (see Section 5.6). However, all students in this cohort participated, thereby ensuring comprehensive representation within the sample. The limited scope aligns with Baxter and Jack's (2008) perspective on the depth-over-breadth trade-off inherent in the case study strategy/methodology.

Another challenge was students' initial unfamiliarity with EGD and related software tools, which necessitated significant foundational learning before they could engage with EdTech-enhanced instruction. This limitation is confirmed by Beetham and

Sharpe (2019), who emphasise the importance of digital literacy as a precursor to effective technology integration in higher education.

Furthermore, students had had minimal prior exposure to HyFlex teaching and learning environments. This unfamiliarity led to apprehension and shaped their perceptions and attitudes towards this instructional approach, which had the potential to affect their engagement and learning experiences. This aligns with a study by Beatty (2019), who identified the complexities of implementing HyFlex models in contexts where learners lacked prior experience with such systems. These limitations underscore the need for a cautious interpretation of the findings and acknowledges the specific context of this study.

7.8 RECOMMENDATIONS FOR FUTURE RESEARCH

Building on the findings (see Chapter 6) and limitations (see Section 7.7) of this study, several areas for further research are proposed to deepen understanding and optimise the integration of EdTech in higher education contexts, particularly for first-year EGD modules for student teachers.

- **Assessing the long-term influence of hybrid learning models (HyFlex).** This study explored the use of the HyFlex model for teaching EGD and its long-term effectiveness regarding student learning outcomes remains uncertain. Future studies could involve longitudinal research to evaluate the sustained impact of hybrid learning and compare student performance and engagement in HyFlex environments to traditional learning settings.
- **Exploring the role of adaptive learning in personalising education.** Adaptive learning technologies offer the potential to customise learning experiences. Research could examine the effectiveness of tailoring education paths for students in practical, complex disciplines such as EGD by focusing on how these tools address individual learning paces and preferences to improve engagement and comprehension.
- **Blended learning and student preferences across disciplines.** Since this study reported varied student preferences for learning environments, future research could explore how preferences for blended learning differ across

academic disciplines. Investigations could also identify which EdTech tools and strategies are most effective for supporting diverse student needs in blended education settings.

- **Examining equity in access to EdTech resources.** Unequal access to digital resources and reliable internet connectivity emerged as challenges in this study. Future studies could focus on strategies to close the digital divide by examining institutional approaches to ensuring equitable access to devices, software and internet connectivity, particularly in under-resourced education settings.

These suggested future research endeavours aim to contribute to the practical and inclusive integration of EdTech in higher education, to enhance both student learning experiences and teaching practices.

7.9 CONCLUDING CHAPTER SUMMARY

This chapter presented a comprehensive overview of the critical components of the research process. This thesis highlights the transformative potential of integrating EdTech in the context of EGD. The findings indicate that, while EdTech tools can enhance student engagement and learning outcomes significantly, their practical implementation is contingent on addressing critical challenges, including digital literacy, equitable access to resources and the adaptability of instruction. Utilising the TPACK framework provided valuable insights into how EdTech can be synchronised with pedagogical strategies to foster a dynamic, HyFlex, student-centred learning environment.

Looking ahead, institutions must prioritise improving digital competencies, establish support systems for both students and educators and ensure equitable access to essential digital tools. This study underscores the importance of adopting a balanced and flexible approach to EdTech integration, in a situation where traditional and digital methodologies complement each other effectively. Such an approach is vital for preparing future educators to navigate and respond to the demands of an education landscape that is continuously evolving in response to the 4IR (see Chapter 4).

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Appendix A: Research letter of information



Research letter of information

The utilisation of EdTech by First Years EGD Student Teachers through a TPACK perspective

Dear Student

My name is Johan Coetzee, and I am currently a lecturer in Technology Education at the University of the Free State. You are invited to participate in a PhD research study exploring the possibilities of making online teaching and learning relevant for first-year Engineering Graphic Design (EGD) students through open-source applications and digital technology.

The Research Ethics Board of the University of the Free State (**UFS-HSD2022/2066**) has approved this study according to the recommended principles of the University of the Free State Ethics guidelines and policies. Before agreeing to participate in this research, I strongly encourage you to read the following explanation of this study's detail:

Background and aim of the study:

This study investigates how EdTech can be integrated and applied to the teaching and learning of prospective technology education student teachers. The rationale for the study is that in a technology-rich world, applying relevant and recent technology is crucial for success.

Participants in this study are expected to do the following:

- You will be requested to sign a Code of Ethics for this study and a consent form.
- Completing a pre- and post-questionnaire that focuses on your familiarity with digital technologies and how often you use these technologies.
- There are no anticipated risks or discomforts from your participation in the study. The only possible risk or discomfort that may arise is that you will be expected to use your device (computer or laptop) for the most significant part of the project.



- Several steps will be taken to protect your anonymity and identity. Your name will never be used, and no identifying information will be revealed.
- Participation in this study is voluntary, and you are free to withdraw consent and discontinue participation in this project at any time without prejudice or penalty.

The research will stretch over ten weeks, during which you will have hyperflex lecturing time. A "hyperflex" approach is highly flexible or versatile. This might involve a combination of in-person and online methods, allowing students to choose between different modes of participation based on their preferences or circumstances. There will be no extra contact time as the contact schedule on the official UFS timetable for 2024.

The results from this study will be presented mainly as a Ph.D. thesis or manuscripts submitted for publication in scientific journals/meetings, seminars, and/or conferences. If you wish to receive a copy of the results from this study, you may contact me at the telephone number below.

You can ask my supervisor any questions during the project (i.e., Dr. Somarie Holtzhausen 051-4012046). If you have further questions once the project is completed, you are encouraged to contact the researcher using the contact information given below. If, as a result of participating in this study, you feel the need for further, longer-term support, you are welcome to contact Johan Coetzee at coetzsj@ufs.ac.za or 083 289 3235.

Thank you very much for your willingness to participate in this research.

Mr. Johan Coetzee

Dr. S.M. Holtzhausen

Has the study received ethical approval?

This study has received approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

Approval number: UFS-HSD2022/2066

Why are you invited to take part in this research project?

The focus of this study will be directed at first-year EGD students. A targeted sample size of approximately twenty students has been selected to participate in this research project, with data collection set to occur during the year 2024.

What is the nature of participation in this study?

The research you will follow will stretch over ten weeks. None of your contact session schedules on the official timetable will be replaced. During these ten weeks, you will be introduced to different EdTech tools and a HyFlex teaching and learning environment. The study involves a pre-intervention and post-intervention questionnaire that should be completed at the research's beginning and end.

Can the participant withdraw from the study?

Participation is voluntary, and there is no penalty or loss of benefit for non-participation. If you decide to participate, you will be given this information sheet and asked to sign a written consent form. You can withdraw at any time without giving a reason for withdrawing.

What are the potential benefits of taking part in this study?

Participating in a study about using EdTech can benefit the individuals involved. Firstly, by participating in such research, individuals can better understand the effectiveness of EdTech in enhancing their learning experiences. Additionally, they can access innovative teaching methods that can improve their skills and knowledge in a particular field. Furthermore, participants can contribute to advancing knowledge in their field of study by providing valuable insights and feedback on using digital tools. Finally, research participation can allow students to develop their research skills and engage in critical thinking, enhancing their future career prospects.

What is the anticipated inconvenience of taking part in this study?

Participating in a study about using EdTech may present some anticipated inconveniences for individuals involved. These may include allocating additional time and effort to complete research-related tasks and provide feedback. Additionally, individuals may need to adapt to unfamiliar digital tools and platforms, which may

require some learning and troubleshooting. Furthermore, the data collection process may involve sharing personal information, which could cause discomfort for some participants. Providing clear instructions and support will minimise any potential inconvenience, and the data collected will be kept confidential and secure.

Will what I say be kept confidential?

Several steps will be taken to protect your anonymity and identity. Your name will not be recorded anywhere, and no one can connect you to the answers you give. Your answers will be given a fictitious code number or a pseudonym, and you will be referred to in this way in the data, any publications, or other research reporting methods, such as conference proceedings. Your answers may be reviewed by people responsible for ensuring that research is done correctly, including the transcriber, external coder, and members of the Research Ethics Committee.

Anonymous data may be used for other purposes, e.g. research reports, journal articles, conference presentations, etc. A study report may be submitted for publication, but individual participants will not be identifiable in such a report. While the researcher will make every effort to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat the information confidentially. I shall, however, encourage all participants to do so. For this reason, I advise you not to disclose personal sensitive information in the focus group. You can stop being in the study at any time without getting in trouble.

How will the information be stored and ultimately destroyed?

The researcher will store hard copies of your answers for five years in a locked cupboard/filing cabinet for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable.

Will I receive payment or any incentives for participating in this study?

It should be noted that participants in this study will not receive any payment or incentives for their involvement. The purpose of this research project is purely academic, and the information gathered will be used solely for the advancement of knowledge in the field of technology education. Any personal information collected during the study will be kept confidential and not used for commercial or financial gain.

Therefore, participants are encouraged to participate in the study of their own volition and interest in contributing to the body of knowledge in their field.

How will the participant be informed of the findings/results of the study?

If you want to know the final research findings, please contact Johan Coetzee at 051 - 4012395 or email coetzsj@ufs.ac.za. The findings are accessible for June 2024 – December 2024. Should you require further information or want to contact the researcher about any aspect of this study, please contact Johan Coetzee at 051 – 4012395 or email coetzsj@ufs.ac.za. Should you have concerns about how the research has been conducted, you may contact Dr Somarie Holtzhausen at 051 401 2046 or email HoltzhSM@ufs.ac.za

Participants in the study may experience some level of inconvenience and/or discomfort in using unfamiliar digital tools or platforms, sharing personal information, and allocating additional time and effort for research-related tasks. No known physical or psychological risks are associated with participating in the study. The only potential risks may include minor inconvenience or discomfort associated with using digital tools or sharing personal information, which researchers will minimise. There is a minimal risk of others identifying a participant's involvement in the study, as all personal information collected will be kept confidential and only used for research purposes. Researchers will ensure that participant anonymity is maintained throughout the study. Thank you for taking the time to read this information sheet and for participating in this study.

Consent to participate in this study

I, the undersigned, _____
(participant's full names to be included), (the "Participant") confirm that I voluntarily agree to participate in the research study referred to as A technological pedagogical content knowledge (TPCK) perspective on integrating digital and online resources for student teachers (the "Study") in relation to a PhD Study and which Study is being conducted by Mr S.J. Coetzee, (the "Researcher").

I, the undersigned Participant, further confirm that–

The researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study.

I have read (or had explained to me) and understood the Study as explained in the attached information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the Study.

I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);

I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information to conduct the Study and any related activities to it;

I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer or otherwise process as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein.

I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage.

I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other higher education institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above.

I, the Participant, agree to the recording of the mixed method data collection.

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

Appendix C: Research study ethics code

Research study Ethical code

In addition to the consent form that participants must sign, this ethical code of conduct is an essential framework for ensuring that the research project is conducted ethically and responsibly. Adhering to this code of conduct will help to ensure that participants are treated with respect, their rights are protected, and their privacy is maintained throughout the study. Moreover, this code of conduct aligns with the Protection of Personal Information Act (POPIA) regulation that safeguards individuals' personal information. Thus, participants can be assured that their involvement in the study will be carried out strictly with the highest ethical standards.

Johnson's 3 P's of Technology Ethics(Johnson, 1999):

1. **Privacy** - I will protect my privacy and respect the privacy of others.
2. **Property** - I will protect my property and respect the property of others.
3. **a(P)propriate Use** - I will use technology in constructive ways and in ways that do not break the rules of my family, church, school, or government

1. Privacy

- No posting of information about anyone without explicit permission.
- ✓ Do not reveal personal addresses or telephone numbers.
- ✓ Recognize that e-mail is not private.
- ✓ Do not use other users' accounts or passwords.
- ✓ Do not post information that is untrue about other individuals.
- Not allow any access to cumulative records or private information.
- ✓ Ensure that all private records are password protected and that no personal password is given to anyone else.
- ✓ Ensure that there is total privacy in the immediate vicinity when accessing private records.
- ✓ When showing student grades, ensure private ID numbers post them.
- ✓ When showing private information to students on your computer, ensure that no other student's information is visible.

- ✓ When posting information on the internet, ensure that the information is stored on a secure server that employs encryption technology to decrease the possibility of interception of private data.

2. Property

- Educators should not post material authored or created by any other individual without his/her permission.
- ✓ Create awareness of copyright laws, including the appropriate use of shareware, government documents, html, java code, freeware, and links to other sites.

3. a(P)propriate

- Refraining from using network resources to store excessive amounts of data, especially non-job related data.
- ✓ Establish and maintain storage limits for individuals on the network.
- ✓ Establish a system for colleagues to monitor space usage

The policy:

The Technology education discipline provides computers and Internet service for students, teachers, staff, and administration. Computers provide access to local, national, and international sources of information.

All users must act responsibly, ethically, and legally following the university's educational objectives. Computer use and access to the Internet is a privilege, not a right. This privilege entails responsibility.

Please read, discuss, and sign the Policy to indicate your full cooperation with the Technology Education Discipline's computer and Internet use policy.

Responsibilities:

- The technology discipline will supervise and provide appropriate guidance and instruction to students using our computer resources.

- Students are expected to demonstrate ethical behaviour when using computers and network resources
- Educational value of Technology Education computer use is the joint responsibility of administration, discipline head, and discipline board members.

Restrictions: The following are NOT permitted:

- Accessing, uploading, downloading, transmitting, displaying, or distributing obscene, profane, lewd, vulgar, rude, inflammatory, threatening or disrespectful language at any time on any computer in the discipline.
- Damaging computers, computer systems, and networks, and spreading computer viruses.
- Posting personal information on the Internet
- Violating copyrights, plagiarism, trespassing in other personal folders, work, or files on all computers
- Violating local, state, or federal statute

Consequences: Consequences for violating these rules will include, but are not necessarily limited to, suspending all technology/computer privileges.

Disclaimer: Technology Education is not responsible for data loss due to faulty connections or equipment failure.

I UNDERSTAND AND AGREE to abide by the guidelines set above policy:

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

Appendix D: EGD first-year student pre-intervention questionnaire

** This questionnaire was converted to a Google Form for the participant's students to complete.*

EGD First Year Student Pre-Intervention Questionnaire **The utilisation of EdTech by First Years EGD Student Teachers through a TPACK perspective**

1. Introduction

Dear Student

EdTech integration in higher education has become essential to modern-day teaching and learning. As the use of EdTech continues to evolve, it is imperative to understand its influence on students' experiences in higher education. In this study, EdTech refer to electronic materials that can be accessed, stored, and distributed electronically, such as e-books, videos, and digital images as well websites, online databases, and digital archives. These resources have become essential components of modern-day education and provide students access to vast information, enhancing their learning experiences.

This questionnaire will establish various aspects of technology usage, including the types of EdTech used, the frequency of usage, and the reasons behind students' choices/preferences (See full details in Research Letter of Information - Appendix A). We will also look at potential challenges and barriers students face when using EdTech in their studies.

The results of this questionnaire will be analysed and form part of a research study for a PhD thesis. There are no right or wrong answers; we want you to answer as honestly as possible. Please answer all the questions.

We appreciate your participation in this survey, and I thank you for taking the time to share your valuable insights with us. Your responses will remain anonymous, and the data collected will be used solely for research purposes. Participation in the survey is entirely voluntary; you can choose to exit the survey at any point.

Conditions and Stipulations* (*Required)

1. By completing this online survey for research purposes, I acknowledge that the information I provide will be held in strict confidence and that my identity will not be disclosed in any reports. I consent to use the data collected from this anonymous survey for research purposes and understand that it may be presented in aggregate formats for public presentations, reports, journals, newspaper articles, or books.
2. I am aware that the online survey aims to investigate my perception and experiences of EdTech within the context of an EGD Module in higher education. All questions in the survey, apart from those related to demographic information, are focused on digital and online resource issues.
3. I acknowledge that my participation in this research survey is entirely voluntary, and I will not be subject to any penalty or loss of benefits for declining to participate. Refusing to participate in this survey will not impact my university status. Additionally, I have the right to withdraw my participation in the survey at any time if I choose to do so. Furthermore, I understand that if I agree to participate in the survey, I may decide not to answer any questions I am uncomfortable answering.
4. All responses in this survey will be treated with the utmost confidentiality to the extent allowed by the technology used. Despite this, it is essential to note that absolute assurance cannot be given regarding the confidentiality of electronic data. Furthermore, survey responses will remain anonymous. Once submitted, the researcher cannot identify participants or remove anonymous data from the database should they choose to withdraw their participation.

Please select only those that apply.

Agree	
Not Agree	

2. Demographic Information

This section of the survey is designed to gather demographic information about you. Please answer all questions to the best of your ability. It is important to note that answering these questions will not reveal your identity, and all responses will be kept completely confidential

2.1 Which type of student are you?

The term "on-campus" refers to students who reside in the campus hostel and conduct most of their studies within the campus vicinity. Conversely, "off-campus" refers to students who reside in private accommodations away from the campus and complete most of their studies outside the campus premises.

Please select only those that apply.

On Campus	
Off-Campus	

2.2 Please indicate your gender.

Please select only those that apply.

Female	
Male	
Other	

2.3 Please indicate your age.

Please select only those that apply.

18 Year	
19 Year	
20 Years	
Above 20 year	

3. Technological Knowledge

This section aims to gather information on your knowledge and usage of EdTech.

3.1 How many Internet-capable devices do you own?

Only include devices you actively use.

One	
Two	
Three	
Four or more	

3.2 Do you own any of these devices?

Mark all applicable devices.

	Laptop
	Tablet or iPad
	Smartphone
	Dedicated e-reader
	Desktop computer

3.3 How do you use each device regardless of whether you own one?

Mark only one per row.

	Haven't used it yet	Use for academic and other purposes	Use for other purposes only
Laptop			
Tablet/iPad			
Smartphone			
Dedicated e-reader			
Desktop computer			

3.4 I could be a more effective student if I were better skilled at using...

Mark only one per row.

	Strongly disagree	Disagree	Agree	Strongly agree
...the course or learning management system (e.g., Blackboard)				
...e-portfolios				
...e-books or e-textbooks				
...simulations or educational games				
...recorded lectures or "lecture capture" (for later use/review)				
...online collaboration tools (e.g. Blackboard Collaborate, Adobe Connect, Google Docs)				
...my tablet during class (for class-related, not personal, purposes)				
...my smartphone during class (for class-related, not personal, purposes)				
...my laptop during class (for class-related, not personal, purposes)				
...social media as a learning tool				
...3D printers				
...non-keyboard or non-mouse computer interfaces, such as voice, touchscreen, and gesture-based interactions				

3.5 What EdTech do you use to complete assignments or projects?

3.6 In the past year (s), to what extent have you used...

Mark only one per row.

	Not used at all	Used in at least one course	Used in about half of my courses	Used in most of my courses	Used in all my courses
...the course or learning management system (e.g., Blackboard)?					
...e-portfolios?					
...e-books or e-textbooks?					
...simulations or educational games?					
...online collaboration tools (e.g. Blackboard)?					
...your smartphone during class (for class-related, not personal, purposes)?					
...your smartphone during class (for class-related, not personal, purposes)?					
...social media as a learning tool?					
...3D printers?					
...non-keyboard or non-mouse computer interfaces, such as voice, touchscreen, and gesture-based interactions?					

3.6 How important is the device you use to your academic success?

(Only indicate the devices you use for study-related work. If you are not using a specific device, just mark not applicable.)

Mark only one per row.

	Not at all important	Not very important	Very important	Extremely Important	N/A
Laptop					
Tablet/iPad					
Smartphone					
Dedicated e-reader					
Desktop Computer					

3.7 Can you describe your experience and confidence in using EdTech (such as PowerPoint, SketchUp, Onshape, TurboCAD, AutoCAD)? What specific skills do you feel strong in, and where might you need further development or assistance?

3.8 To what extent do you agree with the following statements?

Mark only one per row.

	Not Sure	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
I get more actively involved in courses that use technology.						
I am more likely to skip classes when materials from course lectures are available online.						
When I entered university, I was adequately prepared to use the technology needed in my courses.						
Technology makes me feel more connected to what's going on at the college/university.						
Technology makes me feel connected to other students.						
Technology makes me feel connected to instructors.						
In-class use of mobile devices is distracting.						
Regarding social media (e.g., Facebook, Twitter, LinkedIn), I like to keep my academic						

and social life separate.						
I wish I had been better prepared to use institutionally specific technology (e.g., the course registration system, the learning management system, the library search system) when I started college.						
I wish I had been better prepared to use basic software programs and applications (e.g., MS Office, Google Apps, etc.) when I started college.						

3.9 What is your typical in-class experience with the following devices?

Mark only one per row.

	Banned from using it in class	Discouraged from using it in class	Encouraged to use it in class	Required to use it in class	N/A
Smartphone					
Tablet or iPad					
Laptop					

3.10 How often do you use EdTech to collaborate with your classmates or lecturers?

What situations do you find these tools most helpful or necessary, and are there any challenges you encounter when using them?

3.11 If you state 'Never' or 'Rarely' question 3.10, please provide a rationale for your limited use of EdTech for collaboration with your classmates or lecturers."

3.12 Do you think using EdTech has improved your learning experience? Please provide a reason.

3.13 How often do you learn or explore new EdTech?

Mark only one

☐ Never: I don't learn or explore new digital and online resources.	
☐ Rarely: I only learn or explore new EdTech occasionally.	
☐ Often, I frequently learn or explore new digital and online resources.	
☐ Very often, I constantly learn or explore new digital and online resources.	

3.14 If you select 'Never' or 'Rarely' in response to the question, please provide a reason for your limited engagement with new digital and online resources.

4 Pedagogical Knowledge

This section refers to students' understanding of how EdTech effectively facilitated their learning, including instructional design and classroom management.

4.1 Please describe the learning environment where you tend to learn most effectively. Do you prefer a setting with no online components, some online integration, or a fully online environment? Please explain why this environment works best for you.

4.2 To what extent have your courses/learning environments been blended in the past year?

(By "blended", we mean that at least part of your experience was through online delivery of content, and part was through face-to-face interaction with your instructors and that there was some element of control over time, place, and path or pace.)

Check only that applies.

☐	None
☐	A few
☐	About half
☐	Nearly all
☐	All

4.3 In the past year, have you taken a course (or participated in a competency-based programme) offered completely online (i.e. with no formal face-to-face interaction with your classmates or instructors)?

☐	Yes
☐	No

4.4 How do you feel about the role of EdTech in helping you understand Engineering Graphics and Design during your school career? Can you share specific examples where these tools were helpful or unhelpful in enhancing your understanding?

4.5 What pedagogical strategies (Interactive Simulations, Flipped Classroom, Collaborative Online Tools, Adaptive Learning Platforms, Video Lectures and Tutorials, Personal Learning Paths, Online Assessments with Immediate Feedback, Social Media Integration) help you learn through digital and online resources?

4.6 Do you think your lectures have effectively used EdTech in your class?

Mark only one

Strongly disagree: I strongly disagree that my lecturers have used EdTech effectively in my class.	
Disagree: I disagree that my lecturers have effectively used EdTech in my class.	
Agree: I agree that my lecturers have used EdTech effectively in my class.	
Strongly agree: I strongly agree that my lecturers have used EdTech effectively in my class.	

4.6 How has your experience with EdTech impacted your engagement in class?

4.7 How would you describe your teachers/lecturers' ability to integrate EdTech into their teaching? Do you feel they are well-equipped to use these tools effectively? Please share any specific experiences or examples that highlight your perspective

5 Content Knowledge

This section pertains to a student's deep understanding of the subject matter and how EdTech can effectively teach it.

5.1 Do you find EdTech helpful for your study?

Not at all useful: EdTech does not provide any value for my field of study.	
Slightly helpful: EdTech provide limited value for my field of study.	
Very useful: EdTech provide significant value for my field of study.	
Extremely useful: EdTech provide essential value for my field of study.	

5.2 In response to question 5.1, please provide a rationale for your selected rating on the usefulness of EdTech for your field of study."

5.3 Have you ever used EdTech to clarify a complex concept in your field? Kindly provide details.

5.4 How interested are you in a Learning Management System LMS providing you with...

Mark only one per row.

	Not at all Interested	Not very Interested	Very Interested	Extremely Interested
...guidance about courses you might consider taking, such as using "other courses that you might like" or "we recommend" suggestions?				
...alerts if it appears your progress in a course is declining.				
...suggestions on how to improve performance in a course if your progress is substandard?				
...suggestions about new or different academic resources (e.g., tutoring, skills-building opportunities, etc.)?				
...automated tracking of your course attendance via college/university ID card scanners or other automated tracking systems?				
...feedback about your performance compared to other students in your class or your major?				
... personalised support and information on your progress towards your degree goal (through the learning management system)?				
... personalised quizzes or practice questions oriented to your strengths or weaknesses so that you and the instructor know what you need more help on (through the learning management system)?				
... personalised visualisations and dashboards that give you real-time feedback about your progress in a course or learning experience (through the learning management system)?				

5.5 How has using educational technology (EdTech) influenced your understanding of the course content? Can you share examples where it was particularly helpful or where it did not meet your expectations?

5.6 Do you feel that the educational technology (EdTech) available is sufficient to meet the needs of your field of study? Why or why not? Please share specific examples or areas where you believe the tools are either adequate or lacking.

5.7 Are there any EdTech that you feel are missing from your field of study? If yes, please provide a list of such tools.

6 Feedback and Suggestions

6.1 Do you have any feedback or suggestions for improving the use of digital applications and resources for teaching and learning in the classroom on a higher educational level?

7 Conclusion

Thank you for completing the pre-questionnaire on utilising EdTech by undergraduate students pursuing a degree in Technology Education. Your participation in this study is greatly appreciated and will contribute to advancing research in technology education.

Your responses will help us understand how you currently use EdTech to support your learning and your preferences and needs. This information will be used to improve the design and delivery of EdTech to meet your needs as a student better.

We appreciate your willingness to share your thoughts and experiences, and we look forward to analysing the data and sharing our findings with you.

Thank you again for your participation, and we wish you all the best in your academic pursuits.

Sincerely,

Mr SJ Coetzee (Researcher)

Dr S Holtzhausen
Supervisor

Appendix E: EGD first-year student post-intervention questionnaire

** This questionnaire was converted to a Google Form for the participant's students to complete.*

EGD First Year Student Post-Intervention Questionnaire The utilisation of EdTech by First Years EGD Student Teachers through a TPACK perspective

1. Introduction:

The questionnaire aims to investigate the utilisation of EdTech by Engineering Graphics and Design students during their coursework (Ten-week Intervention). Specifically, it seeks to gather data on the frequency and types of EdTech used, their perceived benefits and challenges, and recommendations for future improvements. This questionnaire will be completed following the ten-week intervention period, allowing for an analysis of changes in usage patterns, perceptions, and outcomes resulting from the intervention.

This questionnaire is part of a PhD questionnaire. The findings will have important implications for educators and instructional designers seeking to enhance the quality of engineering graphics and design courses by effectively integrating EdTech. There are no right or wrong answers; I want you to answer as honestly as possible. Please answer all the questions.

The participants' privacy and confidentiality are of utmost importance in research studies. Therefore, no identifying information will be collected to ensure anonymity, and all responses will be kept confidential. Only the researchers involved in the questionnaire will have access to the data collected, and the findings will be reported in an aggregate format to protect the participants' identities.

I appreciate your participation in this questionnaire, and I thank you for taking the time to share your valuable insights with us. Participation in the questionnaire is entirely voluntary; you can choose to exit the questionnaire at any point.

Explaining digital and online resources.

EdTech refers to electronic materials that can be accessed, stored, and distributed electronically, such as e-books, videos, and digital images, as well as online resources, including websites, online databases, and digital archives. These resources have become

essential components of modern-day education and provide students access to vast information, enhancing their learning experiences.

Conditions and Stipulations* (*Required)

1. By completing this online questionnaire for research purposes, I acknowledge that the information I provide will be held in strict confidence and that my identity will not be disclosed in any reports. I consent to use the data collected from this anonymous questionnaire for research purposes and understand that it may be presented in aggregate formats for public presentations, reports, journals, newspaper articles, or books.
2. The online questionnaire aims to investigate my experiences and expectations of digital and online resources within higher education. All questions in the questionnaire, apart from those related to demographic information, are focused on digital and online resource issues.
3. I acknowledge that my participation in this research questionnaire is entirely voluntary, and I will not be subject to any penalty or loss of benefits for declining to participate. Refusing to participate in this questionnaire will not impact my university status. Additionally, I have the right to withdraw my participation in the questionnaire at any time if I choose to do so. Furthermore, I understand that if I agree to participate in the questionnaire, I may decide not to answer any questions I am uncomfortable answering.
4. All responses in this questionnaire will be treated with the utmost confidentiality to the extent the EdTech allow. Despite this, it is essential to note that absolute assurance cannot be given regarding the confidentiality of electronic data. Furthermore, questionnaire responses will remain anonymous. Once submitted, the researcher cannot identify participants or remove anonymous data from the database should they withdraw their participation.

Please select only those that apply.

Agree	☐
Not Agree	☐

2. Demographic Information

This section of the questionnaire is designed to gather demographic information about you. Please answer all questions to the best of your ability. It is important to note that answering these questions will not reveal your identity, and all responses will be kept completely confidential

2.1 Which type of student are you?*

The term "on-campus" refers to students who reside in the campus hostel and conduct most of their studies within the campus vicinity. Conversely, "off-campus" refers to students who live in private accommodations away from the campus and complete most of their studies outside the campus premises.

Please select only those that apply.

On Campus	
Off-Campus	

2.2 What gender do you identify as?*

Please select only those that apply.

	Male
	Female
	Prefer not to answer

2.3 How many hours do you spend using EdTech for educational purposes per week?

Mark only one

	Less than 1 hour
	1 - 5
	6 - 10
	More than 10 hours

3. Technological Knowledge

This section aims to gather information on your knowledge of EdTech and its usage in your Engineering Graphics and Design Course.

3.1 How frequently did you utilise EdTech in your engineering graphics and design courses?"

Mark only one.

Never	
Rarely (once a semester or less)	
Occasionally (2-3 times a semester)	
Sometimes (once a month or less)	
Frequently (more than once a month)	

- 3.2 Kindly provide a comprehensive list of the EdTech you utilise with the most significant frequency in your engineering graphics and design coursework.

- 3.3 To understand your experience and perspective on EdTech in your engineering graphics and design coursework, can you describe your familiarity with it and how confident you feel using it?

- 3.4 Kindly rate your ability to use EdTech effectively.

Very poor ability: I have very little or no ability to use EdTech effectively.	
Poor ability: I have some ability to use EdTech effectively, but it is limited.	
Good ability: I have a good ability to use EdTech effectively.	
Excellent ability: I have an excellent ability to use EdTech effectively.	

- 3.5 Could you please elaborate on any challenges or impediments you may have experienced when using EdTech in your engineering graphics and design coursework? Additionally, kindly explain the measures taken to overcome or mitigate these challenges."

- 3.6 Did the course provide adequate information on the EdTech used?

Mark only one.

Strongly disagree: The course provided no information on the EdTech used in engineering graphics and design coursework.	
Disagree: The course provided little information on digital resources and applications, leaving me feeling underprepared and unconfident in utilising them.	
Agree: The course provided sufficient information on the EdTech used in engineering graphics and design coursework, which allowed me to feel comfortable and proficient in utilising it.	
Strongly agree: The course provided comprehensive and thorough information on the EdTech used in engineering graphics and design coursework, making me feel fully prepared and confident.	

- 3.7 Can you describe your comfort level with the EdTech used in the course? How did your familiarity and confidence with these tools affect your ability to learn, complete assignments, and succeed in the course?

3.8 Did the EdTech help you learn more effectively?

Mark only one

Strongly disagree: The EdTech used in the course did not help me learn effectively and, in fact, may have hindered my learning.	
Disagree: The EdTech used in the course did not have a significant impact on my learning, and I do not believe they helped me learn more effectively.	
Agree: The EdTech used in the course helped me learn more effectively, and I believe it had a positive impact on my understanding of the material.	
Strongly agree: The EdTech used in the course were essential to my learning. I believe they played a significant role in helping me understand the material more thoroughly and efficiently.	

3.9 Please indicate how you learn to use EdTech in your engineering graphics and design courses.

4. Pedagogical Knowledge

This section refers to understanding how Engineering graphics and design were taught using EdTech. It involves knowledge of teaching strategies, instructional design, and assessment methods that incorporate EdTech to enhance student learning outcomes.

4.1 What were the primary teaching methodologies used in the course? For example, lectures, discussions, and project-based learning.

4.2 To what extent did the lecturer incorporate EdTech in these methods, and were they effective in enhancing learning?

Only mark one.

Not at all: The lecturer did not incorporate any EdTech, and they were ineffective in enhancing learning.	
To a small extent: The lecturer used a few EdTech, but they were ineffective in enhancing learning.	
To a large extent: The lecturer incorporated many EdTech, which were primarily effective in enhancing learning.	
Extremely: The lecturer fully utilised EdTech, which were highly effective in enhancing learning.	

4.3 Kindly provide your rating of the level of satisfaction with the use of EdTech in your EGD module.

Only mark one.

Very dissatisfied: I am not satisfied with the use of EdTech in my academic courses.	
Somewhat dissatisfied: I have some reservations about using EdTech in my academic courses.	
Somewhat satisfied: I am satisfied with using EdTech in my academic courses, but there is room for improvement.	
Very satisfied: I am highly satisfied with using EdTech in my academic courses.	

4.4 Please provide examples of effective use of EdTech in your engineering graphics and design module.

4.5 Can you explain your understanding of how EdTech can support learning in Engineering Graphics and Design? Please share any insights or experiences that illustrate your perspective.

4.6 How would you describe the course's opportunities for interaction with your classmates and the lecturer? Were these opportunities sufficient to support your learning, and how might they be improved?

4.7 Did EdTech enhance your engagement in the course content?

Yes	
No	

4.8 Please motivate your answer in 4.7.

4.9 Could you apply what you learned through the EdTech to real-life situations?

Mark One

Strongly Disagree: I couldn't apply what I learned through the EdTech to real-life situations at all.	
Disagree: I could apply what I learned through the EdTech to very few real-life situations.	
Agree: I could apply what I learned through the EdTech to many real-life situations.	
Strongly Agree: I could apply what I learned through the EdTech to all real-life situations.	

4.10 How would you describe the lecturer's use of educational technology (EdTech) in the course? In what ways did the integration of these tools enhance or fail to enhance your learning experience?

4.11 Were there any instances where the EdTech were not used effectively in the course?

4.12 What suggestions would you have for future EGD Modules incorporating EdTech into teaching and learning?

4.13 What is the importance of face-to-face contact with the lecturer in an Engineering graphics and design module?

Mark one

Very low: Face-to-face contact with the lecturer is not at all essential for the Engineering graphics and design course.	
Low: Face-to-face contact with the lecturer is somewhat unimportant for the Engineering graphics and design course.	
High: Face-to-face contact with the lecturer is very important for the Engineering graphics and design course.	
Very high: Face-to-face contact with the lecturer is absolutely essential for the Engineering graphics and design course.	

4.14 What is the perceived level of motivation related to online self-directed learning compared to traditional face-to-face teaching?

Mark one

Very low: Online self-directed learning is much less motivating than traditional face-to-face teaching.	
Low: Online self-directed learning is somewhat less motivating than traditional face-to-face teaching.	
High: Online self-directed learning is somewhat more motivating than traditional face-to-face teaching.	
Very high: Online self-directed learning is much more motivating than traditional face-to-face teaching.	

5. Content Knowledge

Content knowledge refers to a lecturer's understanding of the subject matter and the appropriate instructional strategies to facilitate student learning. Effective use of EdTech in teaching and learning requires a strong foundation in content knowledge and an understanding of how EdTech can enhance students' learning experiences.

5.1 How familiar were you with the content knowledge of engineering graphics and design module?

Mark only one

Not familiar at all: I had never been exposed to or heard of engineering graphics and design courses before taking this course.	
Slightly familiar: I have some basic understanding of engineering graphics and design courses but have not extensively studied or worked in this field.	
Very familiar: I have a strong understanding of engineering graphics and design courses and significant experience with questionnaires or working in this field.	
Extremely familiar: I have a comprehensive understanding of engineering graphics and design courses and extensive experience with questionnaires or working in this field.	

5.2 To what extent did the EdTech used in this course support your understanding and learning of the module concepts? Please provide specific examples of how these EdTech helped enhance your learning experience.

5.3 On a scale of 1 to 4, with one being ineffective and five extremely effective, how would you rate the effectiveness of the EdTech used in this module in helping you learn the course content? Please provide specific examples to support your rating.

Mark only one

		Motivate your answer
1	Not effective at all	
2	Slightly effective	
3	Very effective	
4	Extremely effective	

5.4. How EdTech have helped you improve your engineering graphics and design content knowledge.

5.5 Did the EdTech provide alternative or more varied ways to learn the module content?

Mark one

Very Poor: The EdTech provided no alternative or varied ways to learn the course content.	
Poor: The EdTech provided very limited and insufficient alternative or varied ways to learn the course content.	
Good: The EdTech provided various alternative ways to learn the course content, catering to different learning styles and needs.	
Excellent: The EdTech provided an extensive range of alternative and varied ways to learn the course content, ensuring that all learners could engage with the material effectively.	

6. Conclusion:

I would like to extend my sincerest gratitude for your participation in the questionnaire. Your valuable input has provided me with insights that will help to improve the module and enhance the learning experience.

Please be assured that all your responses will be kept confidential and anonymous. The data collected will be used solely for research purposes and will not be shared with any third party.

Your participation in this questionnaire is much appreciated, and your contribution will go a long way in improving the course's quality. Once again, thank you for taking the time to participate in this questionnaire.

Thank you again for your participation, and we wish you all the best in your academic pursuits.

Sincerely,

Mr SJ Coetzee (Researcher)

Dr S Holtzhausen
Supervisor

Appendix F: Lecturer questionnaire

** This questionnaire was converted to a Google Form for the participant's lecturer to complete.*

Lecturer Questionnaire The utilisation of EdTech by First Years EGD Student Teachers through a TPACK perspective

Dear colleague

Welcome to the questionnaire on using EdTech in the classroom, viewed through the lens of the Technological Pedagogical Content Knowledge (TPACK) Framework. The questionnaire forms part of a Doctoral study titled: "A technological pedagogical content knowledge (TPCK) perspective on integrating EdTech for student teachers."

Ethical clearance was granted by the University of the Free State (UFS-HSD2022/2066). As a lecturer, your experience and perspective are valuable in understanding how EdTech can be integrated effectively to enhance teaching and learning. Thank you for taking the time to participate. The questionnaire will take you between 10 and 20 minutes.

1. INTRODUCTION

This questionnaire aims to gather insights from you as the lecturer on using EdTech in the classroom, focusing on the Technological Pedagogical Content Knowledge (TPACK) Framework. The response will help identify best practices, challenges, and opportunities for improvement in integrating EdTech to enhance teaching and learning to preserve students in technology education, specialised in EGD.

The Technological Pedagogical Content Knowledge (TPACK) framework is a conceptual model that emphasises integrating technology, pedagogy, and subject matter knowledge in teaching and learning. It highlights the importance of understanding how these domains interact to create compelling educational experiences that leverage technology to support learning.

Conditions and Stipulations* (*Required)

1. By completing this online questionnaire for research purposes, I acknowledge that the information I provide will be held in strict confidence and that my identity will not be disclosed in any reports. I consent to use the data collected from this anonymous questionnaire for research purposes and understand that it may be presented in aggregate formats for public presentations, reports, journals, newspaper articles, or books.
2. The online questionnaire aims to investigate my experiences and expectations of EdTech within higher education. All questions in the questionnaire, apart from those related to demographic information, are focused on digital and online resource issues.
3. I acknowledge that my participation in this research questionnaire is entirely voluntary, and I will not be subject to any penalty or loss of benefits for declining to participate. Refusing to participate in this questionnaire will not impact my university status. Additionally, I have the right to withdraw my participation in the questionnaire at any time if I choose to do so. Furthermore, I understand that if I agree to participate in the questionnaire, I may decide not to answer any questions I am uncomfortable answering.
4. All responses in this questionnaire will be treated with the utmost confidentiality to the extent the EdTech allow. Despite this, it is essential to note that absolute assurance cannot be given regarding the confidentiality of electronic data. Furthermore, questionnaire responses will remain anonymous. Once submitted, the researcher cannot identify participants or remove anonymous data from the database should they withdraw their participation.

Please select only those that apply.

Agree	☐
Not Agree	☐

2. DEMOGRAPHICAL INFORMATION

This section of the questionnaire is designed to gather demographic information about you. Please answer all questions to the best of your ability. It is important to note that answering these questions will not reveal your identity, and all responses will be kept completely confidential

2.1 What gender do you identify as?*

Please select only those that apply.

☐	Male
☐	Female
☐	Prefer not to answer

2.2 What is your age?

Please select the appropriate tick box that corresponds to their age range.

☐	25-34 years
☐	35-44 years
☐	45-54 years
☐	55-64 years
☐	65 years or older

2.3 What is your highest level of education?

Please tick the appropriate box representing their highest education level or provide additional information if their education level doesn't fit the provided options.

☐	Bachelor's degree
☐	Honor's degree
☐	Master's degree
☐	Doctorate or professional degree
☐	Other (please specify: _____)

2.4 How many years have you been teaching Engineering Graphics and Design?

Select the tick box representing the years you have taught Engineering Graphics and Design.

☐	Less than one year
☐	1-2 years
☐	3-5 years
☐	6-10 years
☐	More than ten years

2.5 How familiar are you with online teaching applications for Engineering Graphics and Design?

Select the tick box that best represents their familiarity with online teaching applications for Engineering Graphics and Design based on the provided explanations.

☐	1 - Not familiar: I have no experience or knowledge of online teaching applications for Engineering Graphics and Design.
☐	2 - Somewhat familiar: I need more exposure or basic understanding of online teaching applications for Engineering Graphics and Design.
☐	3 - Quite familiar: I have substantial experience and a good understanding of various online teaching applications for Engineering Graphics and Design.
☐	4 - Very familiar: I have extensive experience and a deep understanding of various online teaching applications for Engineering Graphics and Design.

3. Technological Knowledge (TK)

This section aims to assess your technological knowledge and proficiency related explicitly to Engineering Graphics and Design (EGD) in the context of teaching. Please answer the following questions to the best of your ability.

Technological Knowledge (TK) refers to the understanding and proficiency of teachers in effectively using EdTech in the context of teaching Engineering Graphics and Design (EGD). In the teaching of EGD, TK involves having the necessary skills and knowledge to leverage technology for instructional purposes, enhance student learning experiences, and support the exploration and creation of designs.

3.1 Questions related to the knowledge of the EdTech used in teaching

- 3.1.1 What EdTech do you use to enhance student learning and engagement in your courses?
- 3.1.2 Can you describe any strategies you use to ensure that all students have equal access to and familiarity with the EdTech you use in your courses?
- 3.1.3 What role do you see EdTech playing in the future of education, and how can we ensure their use benefits all students?

3.2 Questions related to the ability to troubleshoot EdTech-related issues

- 3.2.1 What challenges have you encountered when using EdTech in the classroom, and how have you addressed them?
- 3.2.2 What are the biggest challenges and opportunities related to EdTech in education in the coming years?
- 3.2.3 What strategies do you employ to help students develop the skills needed for successful technology use?

4. Pedagogical Knowledge (PK)

This section aims to assess your pedagogical knowledge and expertise, specifically in the context of teaching Engineering Graphics and Design (EGD). Please answer the following questions to the best of your ability.

Pedagogical Knowledge (PK) in the context of the Technological Pedagogical Content Knowledge (TPACK) framework refers to the understanding and expertise of teachers in the methods, strategies, and approaches used to teach Engineering Graphics and Design (EGD) effectively. It involves deep comprehension of instructional practices, curriculum development, assessment techniques, and student learning needs in the specific domain of EGD.

4.1 Questions related to instructional strategies and teaching practices

- 4.1.1 Describe your teaching philosophy and how it informs your instructional strategies and techniques.
- 4.1.2 What instructional strategies or teaching practices have you found particularly effective in engaging students and facilitating learning in your courses?
- 4.1.3 Can you describe any changes you have made to your teaching practices over the years and what motivated those changes?
- 4.1.4 How do you approach active learning strategies in your courses and ensure all students can participate?
- 4.1.5 How do you assess student learning in your courses, and what assessments are most effective in measuring learning outcomes?
- 4.1.6 Can you describe any strategies you use to create a positive classroom environment and how you handle any disruptive or challenging behaviour that may arise?

4.2 Questions related to the ability to integrate technology into teaching practices

- 4.2.1 How do you decide which EdTech to use in your courses, and what factors do you consider when making those decisions?
- 4.2.2 What strategies do you use to ensure that all students can access and use the EdTech you use in your courses, regardless of their background or prior experience?

4.3 Questions related to the integration of technology into teaching practices

- 4.3.1 What advice would you give to educators starting to explore using EdTech in their classrooms?
- 4.3.2 Can you share examples of innovative projects or assignments you have designed using EdTech and how they have impacted student learning?
- 4.3.3 How do you balance using EdTech with more traditional teaching methods, such as lectures or discussions?
- 4.3.4 How do you measure the effectiveness of digital and online help in your courses?
- 4.3.5 How do you approach using EdTech tools in the classroom, balancing the potential benefits with the potential risks and challenges?
- 4.3.6 What are some benefits of integrating EdTech into teaching practices, and how can it improve student engagement, learning outcomes, and teacher effectiveness?

- 5.1.3 How do you use your subject matter expertise to design effective and engaging learning activities for your students?
- 5.1.4 How do you balance the need to cover a certain amount of material with ensuring that your students understand the material deeply?
- 5.1.5 How do you assess your students' understanding of the material, and how do you use this assessment to inform your teaching practices?

5.2 Questions related to how technology can support the teaching of the subject matter

- 5.2.1 How can virtual simulations and other digital technologies be used to enhance the teaching of technology education?
- 5.2.2 What are some of the best EdTech available to support teaching technology education and how they can be integrated into the curriculum?
- 5.2.3 How can video and other multimedia resources be used to teach technology education concepts and skills and how they can be used to create engaging and interactive learning experiences?
- 5.2.4 In what ways can technology be used to facilitate collaboration and project-based learning in technology education?
- 5.2.5 How can EdTech support active and student-centred learning in technology education and engaging students in hands-on, experiential, and project-based learning?
- 5.2.6 What are some practical ways to integrate EdTech into technology education courses to create a more dynamic and interactive learning experience and to enhance student learning outcomes?
- 5.2.7 How can EdTech be used to support assessment and evaluation in technology education, such as through online quizzes, tests, and surveys, and to provide students with timely and meaningful feedback?
- 5.2.8 How can technology be used to support the development of critical thinking, problem-solving, and creative skills in technology education courses and to help students develop the knowledge and skills they need to be successful in a rapidly changing technological landscape?
- 5.2.9 How do you ensure your EdTech are accessible to all students, including those with disabilities or other special needs?

5.2.10 What are some strategies for fostering collaboration and communication among students using digital and online resources?

5.3 Questions related to the use of technology to enhance the teaching of specific subject matter

5.3.1 What specific EdTech can be used to enhance the teaching of this subject matter, and how do they support learning objectives?

5.3.2 What are some strategies for using EdTech to differentiate instruction and support the diverse learning needs of students in this subject matter?

5.3.3 What challenges and considerations should lecturers be aware of when using EdTech to enhance teaching this subject matter?

5.3.4 What are some best practices for integrating EdTech into lesson planning and instructional design for this subject matter, and how can lecturers effectively use technology to differentiate instruction and meet the diverse learning needs of students?

6. Conclusion:

Thank you for completing this questionnaire on using EdTech in the classroom, focusing on the Technological Pedagogical Content Knowledge (TPACK) Framework in the context of teaching Engineering Graphics and Design (EGD). Your valuable insights and responses will significantly contribute to our understanding of technology integration in EGD instruction.

By exploring the various dimensions of TPACK, including Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), we aim to gain a comprehensive understanding of your familiarity, proficiency, and expertise in leveraging technology tools and resources to enhance the teaching and learning experiences in EGD.

Your feedback will enable us to identify areas where support and professional development may be needed to enhance further the integration of EdTech in EGD instruction. It will also help us tailor future training and resources to address educators' specific needs and challenges in this domain.

We greatly appreciate your participation and contribution to this study. Your dedication to effective teaching in EGD and the thoughtful integration of technology is pivotal in preparing

the next generation of engineers and designers. Thank you for your commitment and valuable feedback.

Sincerely,

Mr SJ Coetzee (Researcher)

Dr S Holtzhausen
Supervisor

Appendix G: Self-reflection

A 10-week intervention was undertaken to investigate the utilisation of EdTech by undergraduate Technology Education students through TPACK (technological pedagogical content knowledge). This initiative adhered to the five stages of digital integration proposed by TIM (2019). Digital resources and internet apps were methodically included in the curriculum to improve students' learning experiences during this period. When reflecting on the intervention, I used Gibbs's reflective cycle (Robinson, 2024) to thoroughly evaluate the efficacy of the intervention, the difficulties faced, and the knowledge acquired. This self-reflection seeks to offer a thorough assessment of the intervention, emphasising the influence of digital integration on student participation and academic achievements.

As stated in Section 1.2.1, incorporating EdTech entails more than simply utilising a computer to carry out a task. It involves more than simply designating a webpage for classroom use or showcasing a video. Integrating EdTech involves utilising digital tools to enhance learning in numerous formats, facilitate personalised learning experiences for students, foster student engagement, and accommodate diverse learning styles and preferences.

Utilising the five levels of integration of EdTech is essential when implementing digital tools in education, as it offers a systematic and progressive strategy to efficiently integrate these resources (Abucayon, Tangkion and Gapol, 2016). The five steps, namely Entry Level, Adoption Level, Adaptation Level, Infusion Level, and Transformation Level, function as a roadmap to direct educators from their first encounter with EdTech to its complete integration and transformative utilisation (Shaw et al., 2018) (Section 1.2.1). This sequence guarantees that educators and students develop the essential abilities and self-assurance to utilise digital technologies proficiently, consequently improving teaching and learning results.

Critical self-reflection entails thoroughly examining and assessing an individual's assumptions, presuppositions, and viewpoints about the concept of meaning (Mezirow, 2006). Transitions involve managing alterations as persons progress from one phase to another. Engaging in critical self-reflection is an essential skill that can help individuals navigate these transitions by allowing them to reassess and adjust

their current life patterns. Critical self-reflection is distinct from other forms of reflection since it requires individuals to not only comprehend the underlying assumptions guiding their behaviours but also evaluate their importance and develop alternate approaches to action (Mezirow, 2006).

I employed the Gibbs Reflective Cycle to reflect on the 10-week intervention, converting the experiences into substantial conclusions and potential outcomes for the future. The Gibbs Reflective Cycle is a conceptual framework that provides individuals with a systematic approach to engaging in reflection (Robinson, 2024). Graham Gibbs developed this methodology in 1988 to promote learning and personal development by encouraging a comprehensive analysis of experiences (Robinson, 2024). The cycle has six stages:

Step 1: Description: This step provides a comprehensive account of the incident. Necessary inquiries revolve around the following: What happened? When did it happen? Where did it happen? Who was involved? What did you do yourself?

What did other people do? What was the result of these actions (Channell, 2023)?

Step 2: Feelings: People contemplate their affective reactions in this context. Important considerations include: What did you feel leading up to the event? What did you feel during the event? What did you feel after the event? How do you look back on the situation? What do you think other people felt during the event? How do you think others feel about the event now?

Step 3: Evaluation: This phase is dedicated to appraising the favourable and unfavourable parts of the encounter. Queries encompass: What went well during the event or activity? Why was that? What didn't go so well? Why was that? What was your contribution? What contribution did other people make (Channell, 2023)?

Step 4: Analysis: During this stage, the individual thoroughly examines the underlying reasons for the sequence of events. Considerable: What have you learned from the situation, event or activity (Channell, 2023)?

Step 5: Conclusion: This stage aims to provide a concise overview of the knowledge gained from the event. Questions to consider are: To what positive experience did the event, situation, or activity lead? To what negative experience did the event, situation, or activity lead? What would you do differently if the event, situation, or activity were

to happen again? Which skills must you develop in a similar event, situation or activity (Channell, 2023)?

Step 6: Action plan: The ultimate phase entails strategising how to effectively manage comparable circumstances in subsequent instances. In this final step, it is your turn to develop actions for future situations based on the conclusions of step 5 (Channell, 2023).

The Gibbs Reflective Cycle assists individuals in transforming their experiences into practical lessons and future ideas for progress by methodically addressing these stages.

Table 1 offers a detailed self-reflection on the 10-week intervention. The first column provides an overview of the level of EdTech integration, the second column indicates the level according to Gibbs's reflective cycle, and the third column presents the reflection itself.

5 Levels of Implementing the Use of EdTech	Gibbs reflection model	Comments
Entry level At the entry level, lecturers use EdTech to deliver content, while students passively receive information through videos and specific applications. The lecturer is the primary user of digital tools, and student collaboration is minimal and mainly non-digital. Constructive learning involves the lecturer providing information via digital tools, with students passively consuming it. Resources are typically textbook-like and lack real-world context, resulting in no authentic learning. The lecturer manages goal-directed learning through digital instructions and feedback.	Stage1: Description	An instructional approach using Blackboard (Blackboard) as the Learning Management System (LMS) was implemented to deliver course content and track student progress. Students were introduced to the module and course content through a PowerPoint presentation and a walkthrough of their Blackboard module course. This occurred during the first week and initial contact session for the module EGDC1614. The module aims to provide knowledge, skills, and attitudes necessary to demonstrate, identify, and apply EGD techniques, focusing on introductory Engineering, Geometrical, and Mechanical drawings in the FET phase. The session was held face-to-face in the EGD Lab. The introduction to Blackboard was conducted using the LMS, and students followed along on their own devices. Both students and the lecturer were involved. The lecturer provided instructional content, resources, and feedback while students accessed the information, completed tasks, and participated in class activities. As the lecturer, I provided the instructional and welcome video, created PowerPoint slides for lessons, instructed students to work independently on technology-related tasks, and ensured all necessary information was available on Blackboard. I disseminated weekly announcements, monitored student participation through QR codes and an Excel spreadsheet, tracked progress and task completion on Blackboard, and provided feedback on assignments and participation. Students accessed digital resources and online applications, followed instructions to complete tasks independently, scanned QR codes for class participation, and monitored their progress and attendance on Blackboard. They also received guidance and feedback through weekly updates and assignment evaluations. These actions resulted in a structured and monitored learning environment where students could access necessary information, complete tasks, and receive timely feedback. Student participation was effectively tracked, and progress was monitored, contributing to a constructive and organised learning experience.
	Stage 2: Feelings	I experienced a mixture of duty and anticipation before the course and intervention began. I could not wait to use Blackboard (Blackboard) to conduct the intervention, play the welcome video, and observe the kids' reactions. To promote positive learning, I also felt accountable for ensuring all materials and instructions were easily understood and available.

		At this initial level, I felt alert and concentrated. Using the QR code method, I carefully monitored student involvement and tracked their progress on Blackboard. I ensured students had all the tools and knowledge to do their assignments independently by giving them timely feedback. I felt relieved and like I accomplished something after finishing this first level. The work put into organising and presenting the course material was verified by the practical application of the teaching tactics and the enthusiastic reaction from the students. The well-structured and well-organised learning atmosphere that was created satisfied me. In retrospect, I see the circumstances as a successful example of EdTech being incorporated into the beginning level of teaching and learning. It illustrated how well Blackboard (Blackboard) functions as a complete LMS to support self-directed learning, monitor advancement, and offer feedback. The systematic approach enhanced the students' learning experience. Students probably experienced a mixture of curiosity and adjustment at first as they got to know Blackboard and the new style of instruction. When they used the digital tools and finished the assignments, they probably felt more at ease and involved in learning. They felt supported and had a clear path because of the organised comments and updates. These days, I believe that students like the structure and clarity that the Blackboard system offers. Most likely, they are more comfortable utilising digital learning resources and understand the advantages of taking an autonomous, technologically advanced approach to learning. A favourable overall experience was enhanced by the frequent updates and comments, which helped them stay on course and reaffirm what they had learned.
	Stage 3: Evaluation	Implementing Blackboard (Blackboard) as the Learning Management System (LMS) and using digital resources went well. Students could access all necessary information, complete technology-related tasks independently, and receive weekly updates and feedback through the platform. The monitoring of student participation via QR codes and the tracking of progress using Blackboard were also influential. The success was due to the structured and organised approach in utilising Blackboard, providing clear instructions, and ensuring all resources were easily accessible. The timely feedback and consistent updates helped students stay on track and engaged with learning. One potential area that may not have gone as smoothly could be the initial adjustment period for students unfamiliar with Blackboard and the new learning format. This was likely due to the learning curve associated with new technology and the need for students to adapt to a more independent learning approach. Some students might have taken longer to get comfortable with navigating Blackboard and managing their tasks independently. My contribution included preparing and delivering the instructional and welcome video, creating PowerPoint slides for lessons, providing clear instructions for independent tasks, and ensuring all

		resources were available on Blackboard. I monitored student participation, tracked progress, and provided timely feedback and weekly updates. Students contributed by actively engaging with the digital resources, following instructions to complete tasks independently, participating in class by scanning QR codes and monitoring their progress and attendance on Blackboard. Their active participation and adaptation to the new system were crucial to the overall success of the module.
	Stage 4: Analysis	Through this activity, I gained valuable knowledge regarding the principles of successful instruction and education in a technologically advanced setting. Through this activity, I gained valuable knowledge regarding the principles of successful instruction and education in a technologically advanced setting. The utilisation of an informational and welcoming video on Blackboard fostered an inviting atmosphere and delivered explicit guidance on navigating the Learning Management System (LMS), aiding students in comprehending the course framework and prerequisites. Utilising PowerPoint slides in course presentations enhances constructive learning by improving comprehension and memory retention. The learning experience was further enhanced by a guest lecturer's workshop on EGD drawings using PowerPoint. Students were encouraged to autonomously participate in technology-related tasks, fostering self-directed learning and developing technological proficiency as they accessed required knowledge and resources digitally. I pick up that although the students are part of the Generation Z group that there is a huge lack in digital literacy and that time must be spent specifically focusing on the development of their digital literacy. Blackboard provided convenient access to educational resources such as study guides and notes, and kept students informed about assignments and objectives through frequent announcements. Students did appreciate this because they want to be informed on what is going to happen and when it is going to happen. Also they want to know the route ahead. The tracking of student participation was efficiently accomplished through the use of QR code scanning, while progress was closely watched utilising the tools provided by Blackboard. These features captured both student engagement and the completion of assignments. Initially, certain students exhibited hesitance in utilising their mobile devices to scan the QR code for attendance, and they provided various justifications for their inability to utilise their phones. Nevertheless, I discovered that by maintaining a steadfast approach to the technique and showcasing its worth to the students, their initial hesitance transformed into a favourable disposition towards utilising this EdTech. Although this level was during the first two weeks of the semester, I discovered that timely feedback was a necessity for the first years, especially since they are totally new to this new

		learning environment and are very insecure. The use of rubrics, memoranda, and grades on Blackboard sure give them direction and clarity of what is expected. In addition, students had access to weekly attendance records to track their degree of participation. I found that the attendance record on Blackboard functioned as an incentive for students to attend class. Nevertheless, there is a risk that students would solely attend class to obtain the attendance mark. Incorporating academic and practical components, such as PowerPoint for drawing and fulfilling assignments, effectively demonstrated the advantages of a blended methodology. This level highlighted the efficacy of combining technology with conventional teaching approaches to offer a full learning experience, equipping students for a contemporary educational setting.
	Stage5: Conclusion	The utilisation of Blackboard (Blackboard) as the Learning Management System (LMS) for disseminating course material and monitoring student advancement in the EGDC1614 module resulted in numerous favourable encounters. An important advantage was the establishment of a well-organised and supervised educational setting. Students had the ability to obtain all essential information, accomplish assignments autonomously, and receive prompt feedback, resulting in a productive and well-structured learning experience. Negatively to this stage is the fact that the students were not so digital literate as expected. And this encounters a reluctance for the use of EdTech with some students. Time was wasted on simple aspects regarding the use of EdTech. Some students also did not see the value of using EdTech for the teaching and learning environment. If I were to do this activity again, I would prioritise highlighting the wider benefits of active involvement via digital technologies. An effective strategy would involve producing an introductory video that primarily emphasises the usefulness and advantages of EdTech for the course. This movie should stress how EdTech may assist students in completing the module and their future careers as educators. Furthermore, I would showcase the practical application of the knowledge acquired from this course to other subjects. To overcome opposition towards using digital technologies, I recommend providing extensive training and support to enable students to cultivate a sense of comfort and familiarity with the technology. To enhance the incorporation of EdTech in the learning process, I recommend the implementation of more efficient tactics that will enable students to comprehend the concrete advantages of utilising these tools in their education. Essential digital competencies encompass the capacity to produce and modify videos about diverse subjects addressed in the curriculum. In addition, conducting a comprehensive investigation of the online resources accessible throughout the phase of planning the module will enable the discovery of resources that can be customised to each subject.

		Conducting pilot tests with various digital tools before implementing them is essential to detect and address any possible problems in advance, guaranteeing a more seamless learning experience for students.
	Stage 6: Action plan	Objective: Enhance the integration of digital technologies in the EGDC1614 curriculum to optimise student engagement and improve learning results. 1. Emphasising broader advantages: • Create a promotional video highlighting the practicality and benefits of using EdTech in the course. • Demonstrate how EdTech can aid students not just in successfully completing the subject, but also in their future career as educators. • Illustrate the pragmatic utilisation of digital knowledge obtained from the course about other disciplines. 2. Conquering Opposition: • Offer comprehensive instruction and assistance to empower students in developing proficiency and ease with digital technologies. • Provide supplementary resources, such as instructional materials and interactive sessions, to target aspects of digital literacy in which students may encounter difficulties. • Promote the utilisation of peer learning and support networks to cultivate a cooperative atmosphere for enhancing digital skills. 3. Developing Fundamental Digital Skills: • Establish training sessions specifically designed to enhance digital abilities. • Grant students independent access to internet materials and tools to autonomously practise and enhance their digital abilities. • Provide individualised assistance and constructive criticism to students as they enhance their digital skills. 4. Thorough Analyses of Resources: • Perform a comprehensive investigation of web resources about each topic addressed in the module at the initial planning stage. • Identify precise resources that align with the learning objectives and can potentially improve student engagement and understanding. 5. Conducting a preliminary pilot of digital tools: • Before fully implementing, pilot tests using several digital technologies are done to detect any possible concerns or challenges.

		• Collect students' digital literacy input to resolve any problems and implement appropriate modifications. • Ensure that there is easily accessible technical support to aid. (Make use of the tutors for the module to assist).
Adoption level At the Adoption level, lecturers control the EdTech used and guide students through projects step-by-step with the same tools. Students engage in constructive learning by conventionally using digital resources under close lecturer supervision. Collaborative learning happens through the limited use of tools like email. Authentic learning includes guided activities with real-world context, allowing students to apply technology to relevant content. Goal-directed learning involves the lecturer directing students in setting goals and monitoring activities using digital tools.	Stage1: Description	During weeks two and three of the module, students participated in educational activities that focused on the fundamental concepts of EGD. At the Adoption level, I, as lecturer, maintained control over the EdTech and supervised the students in using the same tools to complete projects. Students started the completion of independent assignments involving digital technologies utilising Blackboard as the Learning Management System (LMS). The students were required to utilise PowerPoint to create one of the assigned homework drawings, and subsequently upload it to Blackboard through the provided link. The drawings were assessed online using an electronically generated rubric that was made available to the students when they opened the link to download the assignment. Students were able to view their scores for each category of the rubric as well as the various level descriptions. Additionally, comprehensive feedback was provided for each submission through the use of the text insert feature for PDF documents. Their assignment submission and class attendance were closely monitored to guarantee the active participation and progress of the students. Two further questions were included in the form during the QR code-based class attendance. The questions were primarily aimed at understanding the students' experiences with campus life and their studies and identifying any areas that required attention. These questions were included to assess the students' mental and emotional state after a period of two weeks on campus. The in-person lessons occurred in both the classroom and the ICT lab of the Technology Education building. The parties involved in the activity were the lecturer, responsible for conducting theory sessions, providing resources, and monitoring student progress; the guest lecturer, who delivered a presentation on drawing EGD drawings using PowerPoint; the tutor, who offered tutoring sessions on Learning Outcomes and drawing with PowerPoint; and the students, who actively participated in lessons, completed assignments, engaged in class discussions, and filled out questionnaires. As the lecturer, I conducted two two-hour theory sessions on the Learning Outcomes, elucidated the hyperflex teaching and learning environment, furnished materials on Blackboard, supervised student engagement and progress, provided updates and comments, and directed students in completing their responsibilities. The guest lecturer delivered a second two-hour presentation on creating EGD drawings using PowerPoint, while the tutor offered a two-hour tutoring session on Learning Outcomes and drawing with PowerPoint. Students participated in sessions, fulfilled homework assignments, utilised QR tags for recording their involvement, accessed materials and submitted assignments using Blackboard, and completed Questionnaire 1 of the Research Project.

		The outcome of these measures was establishing a well-organised and well supervised learning environment, in which students actively participated in constructive learning using digital resources. The individuals utilised all the materials available on Blackboard, actively engaged in classroom discussions, and effectively fulfilled their assignments. Efficient monitoring of participation and progress was achieved by utilising digital resources such as QR codes and Blackboard LMS. Additionally, students were able to maintain their learning objectives with the aid of weekly updates and feedback. Students were provided with a comprehensive weekly schedule that included specific sections for the week's objectives, learning activities, assessment activities, and additional resources related to the topic, such as PowerPoint slides, videos, and website links. In addition, they were provided with precise details regarding the specific time and location of their classes. The integration of face-to-face and virtual resources enabled a thorough and all-encompassing learning experience.
	Stage 2: Feelings	A feelings evaluation was conducted using the weekly attendance QR code to measure students' experiences with EdTech, specifically in regards to obtaining all their modules work and assignments online and using digital programmes for drawing. The response received was predominantly favourable, which generated in me a sense of enthusiasm to integrate structured learning activities and technological resources in order to guarantee that students obtain a comprehensive educational experience. Nevertheless, I maintained a keen understanding of the significance of maintaining authority over the technology in order to proficiently direct the students. Observing students actively utilising digital resources and engaging in the learning process during the activities was gratifying. By closely monitoring their progress and offering immediate feedback, I was able to maintain my focus and dedication to helping their learning. Following the event, I experienced a feeling of achievement and contentment. The systematic methodology and use of digital resources greatly facilitated the students' acquisition of knowledge, while their enthusiastic engagement and favourable responses further validated the efficacy of the educational endeavours. Additionally, there was a sense of alleviation, as it was acknowledged that the intended tasks and evaluations had been accomplished with success. After thorough review, I view what happened as a successful implementation of a mixed learning approach. The combination of face-to-face classes, tutorials and online resources provided a full educational experience. The careful preparation and monitoring ensured that students remained actively engaged and adhered to the schedule, resulting in a highly satisfactory teaching experience. In my view, the students encountered a blend of challenging assignments and support. The use of digital tools and self-directed tasks likely compelled them to acquire novel proficiencies, while the organised instruction and feedback offered a support system to facilitate their achievements. The guest lecturer and tutor probably experienced a feeling of cooperation and mutual accountability in improving the students' educational experience.

		Now, it is likely that others feel grateful for the organised and well-supported educational setting. Students are likely to acknowledge the advantages of the digital tools and feedback systems that aided their comprehension and enhancement of their skills. The guest lecturer and tutor may experience a sense of fulfilment regarding their contributions to the students' advancement and the overall triumph of the educational endeavours. Throughout the session, I experienced a profound sense of involvement and focused attention.
	Stage 3: Evaluation	During this stage, I reflect on the positive and negative aspects of the interaction. At the Adoption level, I, as the lecturer, exerted authority over the EdTech and supervised the students in utilising the same tools to accomplish their tasks. Students proficiently fulfilled individual tasks by utilising digital technologies through Blackboard, the Learning Management System (LMS). They using PowerPoint to generate homework illustrations and submitted them for evaluation. The achievement can be attributed to the organised setting and explicit instructions, which enabled students to comprehend and utilise digital tools effectively. The digitally produced rubric offered clear grading standards and feedback, improving educational results. A comprehensive feedback mechanism was implemented, where students were provided with detailed comments on their submissions using the text insert capability specifically designed for PDF documents. This approach facilitated the provision of precise and practical feedback, enabling students to comprehend their errors and identify areas in need of enhancement. Memo's of each drawing was also made available to the students online and could be accessed by students at any time. The memo's were drawn by using digital software named TurboCad. It was uploaded well in advance in a dedicated folder on Blackboard and the active release was set in such a way that the memo of a specific assignment was only available for students to view after the due date and time of the specific assignment. The continuous use of QR codes for attendance and participation facilitated dynamic student involvement and supervision. By incorporating supplementary inquiries regarding campus life and academic pursuits, student requirements were discerned, hence fostering a nurturing educational atmosphere. Unfortunately, some obstacles in assimilating new technologies began to emerge. Students showed challenges in using the new digital tools and platforms. A lack of digital literacy, particularly in using basic functions of PowerPoint, became evident as the complexity of the drawings increased. Some students found it difficult to adapt to digital tools such as PowerPoint for drawing, even after attending training sessions, because they had different levels of prior experience. This highlighted the need for extra training and assistance on using specific applications. Additionally, not all students had their own laptops, making it difficult for some to put in extra effort. These students had to visit the computer labs, which was a challenge in itself. The computers in

		the EGD lab were also outdated, and the institution's Wi-Fi was sometimes very slow. This caused frustration when using EdTech to complete assignments. As the lecturer, I conducted two two-hour theoretical sessions on Learning Outcomes, explained the hyperflex teaching and learning environment (that will be followed from the next week onwards), provided materials on Blackboard, supervised student participation and progress, provided updates and feedback, and directed students in fulfilling their responsibilities. The guest lecturer delivered a comprehensive two-hour presentation on the creation of EGD drawings using PowerPoint, providing authoritative perspectives and hands-on demonstrations. The instructor delivered a two-hour lesson on Learning Outcomes and drawing using PowerPoint, offering supplementary support and clarifications to the students. Students exhibited high levels of involvement in lessons, conscientiously finished tasks, actively contributed to class discussions, and completed questionnaires. They employed QR codes to record their involvement and utilised Blackboard to retrieve resources and submit assignments. The collaborative endeavours yielded a meticulously structured and closely monitored educational setting, wherein students actively participated in productive learning activities utilising digital resources. The usage of QR codes with Blackboard LMS allowed for effective monitoring of participation and development. Students preserved their learning objectives by the assistance of regular updates and feedback. The combination of in-person and online resources facilitated a comprehensive and in-depth learning experience, bolstered by a well planned The collaborative efforts resulted in a highly organised and well supervised educational environment, where students actively engaged in productive learning activities using digital resources. The use of QR codes into the Blackboard Learning Management System facilitated efficient tracking of engagement and progress. Students maintained their learning objectives through the aid of consistent updates and feedback. The integration of face-to-face and virtual resources provided a thorough and detailed learning experience, supported by a carefully designed weekly schedule that outlined goals, tasks, evaluations, and additional materials.
	Stage 4: Analysis	Weeks two and three of the module offered valuable insights into integrating EdTech in education, particularly for EGD. As a lecturer, maintaining control over EdTech and supervising students' use of these tools was crucial for a consistent learning experience. Establishing a well-organised and supervised learning environment was key, achieved through clear instructions, structured weekly schedules, and the utilisation of Blackboard LMS, which facilitated a comprehensive learning plan with objectives, activities, assessments, and additional resources. Requiring students to use PowerPoint for homework drawings and submit them via Blackboard introduced practical digital tools and provided transparent grading criteria and comprehensive feedback through an electronically generated rubric. Despite the structured environment, some students struggled with digital tools like PowerPoint, highlighting the need for extra training to ensure all students reached a basic level of digital literacy. This contradicts the findings outlined in

		the literature review. As demonstrated in Section 3.2.4 regarding Digital Skills and Technological Proficiency, a significant proportion of Generation Z students exhibit a high level of proficiency. Generation Z students are widely acknowledged in the contemporary educational landscape for their exceptional digital fluency and adeptness with technology, embodying a cohort that has come of age in an era characterised by rapid technological advancements and digital innovation (Seemiller & Grace, 2015). Additionally, not all students had personal laptops, necessitating visits to computer labs with outdated equipment and slow Wi-Fi, which caused frustration and hindered assignment completion. The use of detailed feedback through PDF text inserts and TurboCad-drawn memos provided valuable insights into students' performance. Active participation and monitoring were facilitated through QR codes for attendance and participation, allowing efficient tracking of progress and understanding of students' experiences. The involvement of a guest lecturer and tutor added depth to the learning experience, enriching students' understanding and skills through sessions on EGD drawings and learning outcomes. Assessing students' mental and emotional states through QR code-based attendance questions helped create a nurturing environment addressing their broader needs. Reflecting on the success of the mixed learning approach, which combined face-to-face classes, tutorials, and online resources, I learned the importance of a well-structured, supervised learning environment that balances digital and traditional teaching methods. The integration of comprehensive feedback, continuous monitoring, and addressing students' broader needs significantly contributed to the successful adoption of EdTech in education.
	Stage 5: Conclusion	The teaching and learning activities carried out as well as the specific use of digital resources and online applications in weeks two and three of the curriculum yielded several positive effects. At first, the establishment of a highly organised and carefully supervised educational environment enabled students to actively engage in effective learning by using digital tools. The utilisation of technological aids such as Blackboard and PowerPoint facilitated the prompt submission, evaluation, and provision of feedback for assignments, resulting in improved educational outcomes. Through the integration of both face to face and online resources, students were able to get advantages from a comprehensive learning experience, which was supported by meticulously planned weekly schedules and clear-cut instructions. Furthermore, the utilisation of QR codes for tracking attendance and engagement has created a conducive atmosphere, allowing for efficient monitoring of student progress and understanding of their educational encounters. Overall, the activities enhanced student engagement, academic performance, and satisfaction with the educational process. However, despite the positive interactions, various challenges were also encountered. Notably, students faced difficulties in adapting to new digital tools like PowerPoint, mostly because of

		varying levels of prior experience and limited access to personal laptops. The existence of outdated equipment and slow Wi-Fi in computer labs further hindered the prompt completion of tasks, resulting in student dissatisfaction. These issues highlighted the need for additional education and support to improve digital literacy and provide equitable access to technical resources. To successfully address these difficulties in the future, numerous improvements could be done in anticipation of similar behaviours. Firstly, expanding the range of training sessions on digital tools and offering support to students with limited access to personal laptops could improve digital literacy and reduce technological barriers. Furthermore, providing assistance for the installation of advanced technology and improved Wi-Fi infrastructure in computer laboratories would enhance students' ability to effectively utilise digital resources. Furthermore, using supplementary interactive and engaging educational methods could promote dynamic learning and enhance student engagement and satisfaction. Gaining proficiency in a wider range of digital tools and platforms would be beneficial for effectively promoting student learning in similar activities, particularly in terms of skill enhancement. Enhancing the ability to create and implement extensive training programmes for digital literacy would also be advantageous in addressing varying levels of student competence. Furthermore, improving expertise in managing and advocating for electronic resources would provide equitable access to resources and promote student success in digital learning environments. By focusing on these specific areas for development, future iterations of comparable events have the potential to significantly enhance student learning and engagement.
	Stage 6: Action plan	To manage comparable circumstances in subsequent instances effectively I think that there should be focused on the following five aspects. Streamlined Digital Literacy Training: Create and execute a set of inclusive training sessions aimed at introducing students to a variety of digital tools and platforms, with a particular focus on becoming proficient in PowerPoint and Blackboard features. These sessions should be designed to accommodate students with different levels of experience and help them develop the essential skills to effectively use digital resources for their academic needs. Improving Access to Technological Resources: Support the implementation of modern technology and enhanced Wi-Fi infrastructure in computer labs to resolve problems associated with outdated equipment and sluggish internet connectivity. In addition, consider ways to support students who may not have their own laptops, so that all students have equal access to technology resources. This is a matter that needs the attention and support from the institution authorities as well. It might be positive to also talk to the Teaching and learning divisions of the faculty as well as the institution. Enhance the learning experience by incorporating interactive and engaging educational methods into instructional activities. This will promote dynamic learning and increase student engagement

		and satisfaction. This may involve incorporating various multimedia resources, interactive learning experiences, and collaborative projects that utilise digital tools and platforms. Professional Development for Educators: Offering educators the chance to improve their skills in managing and promoting electronic resources, as well as creating and executing comprehensive training programmes for digital literacy. There are various options available for professional development in the field of instructional technology and effective pedagogical practices in digital learning environments. These options may include workshops, seminars, or online courses. This is once again a matter that needs to be discussed with the Centre of Teaching and Learning. In accordance with the action plan of level 1, it is important that effort must be put in form the lecturer side to develop in the use of digital resources and online applications. This development closely links to the suggestion of Education 4.0 as seen in Section 4.2.1. Implementing a system for continuous assessment and improvement of educational activities involves seeking feedback from students and other lecturers to identify areas for enhancement. Consistently evaluating and adapting teaching methods, technological tools, and support systems will enhance the success of future similar events in fostering student learning and involvement. Through the implementation of these measures, the aim is to tackle the difficulties faced in past teaching activities and improve the overall efficacy of educational pursuits moving forward. By implementing enhanced digital literacy training, providing access to technological resources, utilising interactive learning methods, offering professional development for educators, and implementing continuous assessment and improvement, we aim to establish an optimal learning environment that fosters student engagement, academic performance, and satisfaction.
Adaptation level At the Adaptation level, lecturers integrate EdTech into lectures, though they still decide which tools to use. Students work independently with these tools. Collaborative learning is encouraged through EdTech. Constructive learning occurs as students use digital tools to build concepts and explore their applications independently. Authentic learning begins as students use EdTech in activities related to their lives	Stage1: Description	During weeks five and six of the intervention, I seamlessly integrated EdTech into my lectures, allowing students to start to choose the most effective tools. Students were motivated to engage in independent work using these tools, fostering a culture of collaborative learning through EdTech. Students could engage in constructive learning by using digital tools to develop their understanding of concepts and independently explore how they can be applied. In addition, authentic learning emerged as students actively participated in EdTech activities relevant to their lives and more significant societal concerns. I facilitated goal-directed learning by providing guidance and tools for students to set, plan, and evaluate their activities. During week 5, a test was administered using traditional drawing equipment and computers. The test consisted of two questions. The first question asked students to use traditional drawing methods with a pencil and paper. The second question required students to draw their answers using PowerPoint as a drawing application, following SANS Drawing standards. Students turned in a physical copy of Question 1 at the test location, while they submitted a digital version of Question 2 through a provided link on the Blackboard (Blackboard) LMS system. Throughout the week, students took advantage of digital resources and online applications in a way that encouraged a deep understanding of the concepts and meaningful engagement with the

and broader issues. Goal-directed learning involves the lecturer selecting tools and guiding students to set goals, plan, and evaluate activities.		tools. Student class participation was again efficiently monitored through QR code scanning at the beginning of each class, and student progress and task completion were tracked using the Blackboard Learning Management System (LMS) monitoring system. In addition, students were given regular updates on the module's tasks and objectives and feedback on their assignments submitted on Blackboard (Blackboard). During week 6, students independently engaged in a self-study class, delving into LU 4: First angle orthographic projection and LU 5: Assembly drawings. The tutor conducted in-person tutorials on drawing with OnShape, a new digital drawing application introduced to the students. Students were also given three concise videos on First Angle Orthographic drawings, relevant YouTube video links, and website addresses. Therefore, students did not have a formal face-to-face session with me as the lecturer, as I was only available via email for any enquiries. Students, thus, were allowed to work entirely on their own. They were encouraged to work together and assist each other through peer learning. Two assignments were given to the students to complete. The first involved drawing with a pencil on a drawing sheet, while the second required drawing using OnShape. The completed assignments were then submitted through a Blackboard (Blackboard) link. Throughout the week, students were encouraged to use technology tools independently, while the I facilitator role was to promote and assist with increased student engagement. Like previous weeks, student class participation was monitored by scanning QR codes, and their progress was tracked using the Blackboard LMS monitoring system—regular updates and assignments through Blackboard (Blackboard) to help them stay on track and receive guidance. In addition to the weekly QR code attendance, I had two new questions that focused on students' experience using PowerPoint to answer a test question. The feedback was overall positive. The slow computers and internet were still a point of concern. In addition, a questionnaire was sent to the lecturer of the second-year cohort to gather information about the use of EdTech in the classroom. The purpose of this questionnaire was to explore effective methods, obstacles, and possible ways to enhance teaching and learning experiences by incorporating EdTech and engaging students in technology education. The questionnaire was created using Google Forms, and the Visla online application was used to create a video explaining the reasoning behind its development. Both components were then sent to the lecturer via an interactive email.
	Stage 2: Feelings	Prior to incorporating EdTech into this level, I experienced a blend of anticipation and enthusiasm. The prospect of increasing student engagement and promoting a collaborative learning atmosphere was quite inspiring. Still not knowing how the students will deal with the fact that they need to start working now on their own and have a complete week of teaching and learning only using online resources and digital applications, makes me quite nervous for this level.

		As I introduced digital tools, I was filled with hope and inspired by the students' eagerness and openness to delve into these innovative resources. The smooth incorporation of technology and the students' enthusiastic participation in both individual and group learning were highly satisfying. After considering the situation, I felt a great sense of achievement witnessing how students skillfully employed digital tools to enhance their comprehension and put concepts into practice. It was reassuring to hear positive feedback from students about their experiences with the technology, even though they faced challenges such as slow computers and internet issues. Looking back, I see the situation as a positive move towards updating the educational experience. The students' capacity to adjust and flourish in a technology-enhanced setting underscores the success of the intervention. During the implementation, it seems that students experienced a mix of emotions, ranging from anticipation to some level of nervousness. The new tools and methods were initially unfamiliar, but their enthusiastic participation and positive feedback indicate they found the experience valuable and captivating. It seems that students are starting to recognise the importance of incorporating EdTech into their educational pursuits. It is probable that their initial enthusiasm has now evolved into an understanding of the tangible advantages and improved educational results. In Week 5, a test was conducted using both traditional and digital drawing tools, and the submissions were handled through the Blackboard LMS. During Week 6, students explored and practiced using digital drawing applications and resources. They were able to submit their assignments digitally, making the process more convenient and efficient. Overall, the process encouraged a culture of working together, providing helpful feedback, and engaging in genuine learning experiences, with the assistance of digital platforms. The success of the intervention highlights the significance of incorporating digital tools in education to improve student engagement and learning outcomes.
	Stage 3: Evaluation	During weeks five and six of the intervention, a comprehensive evaluation of the interaction highlights both positive and negative aspects. One positive aspect of this period was the smooth incorporation of EdTech into lectures, allowing students to choose the most suitable tools for their learning. This integration encouraged students to participate in self-directed activities, promoting cooperative learning with the help of digital tools. Students showcased a profound grasp of concepts and active involvement with the tools, enabling them to enhance their comprehension and delve into practical applications. Authentic learning became apparent as students engaged in technology activities that were meaningful to their lives and addressed important societal issues. In addition, goal-directed learning was successfully implemented by offering students guidance and tools to set, plan, and evaluate their activities. Nevertheless, some difficulties arose. Despite receiving positive feedback, ongoing issues with slow computers and internet connectivity problems disrupted the seamless execution of digital activities. In addition, the anticipation and nervousness that arise before incorporating EdTech

		suggest that there may be initial uncertainties among the lecturer and students. However, the enthusiasm and receptiveness shown by students when digital tools are introduced indicates a readiness to embrace and investigate new resources. In week five, a test demonstrated the convenience and efficiency of digital submissions through the Blackboard LMS system. The test utilised both traditional and digital drawing tools. Week six was a time for students to take charge of their own learning. They explored digital drawing applications and resources and submitted their assignments digitally. The transition to digital submissions has made the process more efficient and fostered a culture of collaboration in learning. The intervention showcased the importance of integrating digital tools into education to improve student engagement and academic achievements. Although there were some difficulties, the favourable response from students and the seamless incorporation of digital resources highlight the potential advantages of technology in education. The experience highlights a move towards a more innovative and effective educational approach, emphasising the significance of embracing digital tools to facilitate genuine learning experiences.
	Stage 4: Analysis	The progression level, especially during weeks five and six of the intervention, was carefully planned to gradually incorporate EdTech into the educational setting. The first step was to smoothly incorporate digital tools into lectures, giving students the freedom to choose the most suitable resources for their learning. This phase was designed to encourage student engagement and motivation by giving them the opportunity to choose how they learn. This approach promotes a culture of collaboration and self-directed learning, utilising EdTech. During week five, a crucial moment arose when the application of digital tools was tested in a practical examination scenario. This assessment assessed students' comprehension and skill in traditional drawing techniques, while also familiarising them with digital drawing tools like PowerPoint, using established procedures. The test administration provided students with a practical opportunity to apply their knowledge using digital tools. Additionally, it offered valuable feedback on the effectiveness and usability of these tools. After the test, week six was all about independent exploration and practice with digital drawing applications. Students were encouraged to explore specific topics, such as First Angle Orthographic Projection and Assembly Drawings, using digital resources and tools like OnShape. This phase focused on empowering students to become active participants in their own learning, encouraging them to develop independence and self-reliance. It also ensured that they received the necessary support and guidance to achieve success. During the two-week period, different methods were used to keep track of student progress and involvement. These included using QR code scanning to record attendance and utilising the Blackboard LMS system to monitor tasks and provide feedback. These mechanisms were put in place to ensure that students stayed on track and received timely support and guidance as necessary, which enhanced their learning experience.

		Through the utilisation of digital applications and online resources, a number of valuable insights were gained. First and foremost, the process emphasised the significance of being flexible and adaptable when incorporating new technologies into education. Although there were some initial uncertainties and challenges, the positive response from students and their openness to using digital tools highlighted the potential advantages of technology-enhanced learning environments. In addition, the experience highlighted the importance of continuous support and guidance to assist students in effectively utilising and maximising the potential of digital resources. Ultimately, the seamless incorporation of digital tools showcased the benefits of integrating technology into education, enhancing student engagement, improving learning outcomes, and enriching overall educational experiences.
	Stage5: Conclusion	Throughout weeks five and six of the intervention, incorporating EdTech into lectures provided valuable insights. This approach enabled students to select the most suitable tools for their learning, promoting active participation, enthusiasm, and a climate of cooperation and independent learning. Students engaged with digital tools to enhance their comprehension of concepts and apply them to practical, real-world problems, leading to genuine learning opportunities. The test in week five provided a hands-on experience that allowed students to explore the practicality of combining traditional and digital drawing methods. Additionally, it offered valuable feedback on the effectiveness and user-friendliness of digital tools. Nevertheless, the smooth execution of digital activities was disrupted by challenges such as slow computers and internet issues. In the future, it will be essential to prioritise the establishment of a dependable technology infrastructure. Students must receive ongoing support and guidance to make the most of digital resources. Some areas to focus on for similar events are improving troubleshooting skills for technical issues and finding more effective ways to provide remote support. The intervention showcased how digital tools can improve student engagement and learning outcomes, emphasising the importance of adaptability and strong support systems in technology-enhanced education.
	Stage6: Action plan	After analysing the findings from weeks five and six of the intervention, here are some recommended actions to enhance future situations: Improve Technology Infrastructure: Work together with the IT department to enhance computer hardware and guarantee fast internet connectivity in the classroom. Offer ongoing assistance and direction: Consider implementing a specialised helpdesk or support team to provide assistance to students encountering technical difficulties or needing guidance with digital tools. This benefit ensures that students are able to utilise digital resources and receive prompt assistance, thereby enhancing their overall learning experience.

		Enhance Your Troubleshooting Abilities: Coordinate workshops for the tutors that will then be able to address technical issues and give remote assistance. This will make it possible to effectively address concerns, ensuring a smooth continuation of teaching and learning activities. Developing contingency strategies is crucial. Take proactive measures to prepare for technical failures by developing contingency plans. These plans should include options for alternative assignments or offline resources to ensure a smooth academic experience. This will minimise the disruption by unforeseen technical issues during the teaching and learning process. Promote a culture of collaboration to enhance the learning experience: Encourage peer learning and collaboration by incorporating group projects and peer review sessions using digital tools. This approach promotes a more interactive and cooperative learning environment, allowing students to learn from each other and develop important teamwork skills. By leveraging digital tools, students can easily collaborate and provide feedback to their peers, fostering a more engaging and enriching academic experience. Consistent Evaluation and Feedback: Take the initiative to regularly conduct surveys and feedback sessions with students in order to evaluate the effectiveness of digital tools and pinpoint areas that can be enhanced. Keep track of and assess progress: Take advantage of analytics tools available in the LMS to monitor student engagement and performance. This will provide valuable insights based on data, which can be used to enhance teaching strategies. By implementing these strategies, future interventions can better incorporate EdTech into the educational setting, improving student engagement and learning outcomes while addressing potential challenges.
Infusion level At the Infusion level, various digital tools are seamlessly integrated into teaching and freely available to students. Students actively learn by choosing and frequently using specific digital tools. Lessons support the self-directed use of technology, fostering a collaborative environment.	Stage 1: Description	Throughout weeks seven, eight, and nine of the intervention and module, a range of digital technologies were smoothly included in the teaching and learning process. Recently, topics such as assembly and pictorial drawings, notably isometric, oblique drawings, and one-point perspective, have been emphasised. Students engaged in teaching and learning by actively choosing and regularly utilising specific digital tools. During these weeks, pupils primarily worked autonomously. Topic-specific films and notes were published on Blackboard (Blackboard) as digital resources for students. The tools were available through an interactive electronic Blackboard document, including links to movies, notes, quizzes, and homework assignments using QR codes. Students utilised conventional drawing techniques using pencils to finish their assignments. Still, they were subsequently acquainted with the process of scanning and turning their drawings into PDF format

Constructive learning happens as students select tools to understand concepts. Authentic learning is enhanced with access to diverse resources, allowing the exploration of personal interests. Goal-directed learning becomes flexible as students use various tools for planning, monitoring, and evaluating their work.		using their mobile devices. The assignments were scanned and subsequently uploaded to Blackboard via the provided links in the e-document. A variety of software solutions were utilised to optimise the learning experience. Visla and Renderforest were utilised to produce interactive films featuring subtitles and elucidations. Create Studio, Doodle, and TurboCad were utilised to generate supplementary movies on the given subjects. AI tools such as ChatGPT were employed to produce interactive electronic notes, while Piktochart and Vimo were utilised to build the interactive working document. Blackboard functioned as the Learning Management System (LMS) to post quizzes. In the eighth week, students utilised AI Software Gamma to generate a PowerPoint presentation centred around their electronic notes. In addition, students were given hyperlinks to YouTube videos and specific websites relevant to the subjects. In week nine, Feedback Fruits was utilised to provide the e-notes. Students were obligated to respond to distinct inquiries at different phases of the document before proceeding with their tasks. Despite students working autonomously, in-person tutoring sessions were still conducted, specifically on sketching using OnShape. A collaborative session was arranged for week eight utilising Blackboard Collaborate. Additionally, students filled out an anonymous questionnaire using Microsoft Forms to provide feedback on their experiences with the module. The input provided enabled the lecturer to address issues and effectively pinpoint areas that want improvement. As an educator, I deliver instructional content, and students choose suitable technological resources. Individuals must possess the necessary knowledge and judgement to make well-informed choices regarding utilising various digital resources and online technology. The education prioritises student learning rather than solely emphasising the technology instruments. Students cultivate a comprehensive comprehension of diverse digital tools, empowering them to discern and employ the most appropriate ones for their activities on a consistent basis. The lectures are structured to foster student autonomy and independence by encouraging self-directed use of technology. Student class participation was monitored by implementing a mandatory QR code scanning process at the beginning of each lesson. A Microsoft Excel spreadsheet provided a concise overview of student engagement. The Blackboard LMS monitoring system was used to track student progress and task completion by recording the frequency and timing of students' access to their assignments. Students were given advice and feedback on the programme through weekly updates regarding upcoming activities and objectives. Feedback on assignments was delivered via publishing the assignment rubric, memo, and grade on Blackboard. In addition, the weekly attendance was recorded on Blackboard, providing students with a convenient way to track their involvement.

	Stage 2: Feelings	During weeks seven, eight, and nine of the intervention and module, students had various emotional responses to introducing digital devices. Before the event, students may have experienced excitement and unease around incorporating novel digital technologies into their educational journey. Participants likely encountered enthusiasm and difficulty throughout the session as they interacted with various technologies. The freedom to select and utilise these tools may have cultivated a feeling of empowerment but also instances of irritation as they manoeuvred through unfamiliar software. Following the event, students likely experienced a feeling of achievement in acquiring proficiency with these tools and successfully finishing their projects, along with a sense of satisfaction in overcoming any challenges. In retrospect, students may acknowledge the significance of digital literacy in their education, appreciating the skills and knowledge acquired. Peers and educators probably had a mix of interest and support during the session, recognising the significance of incorporating EdTech into contemporary education. Now, some individuals may perceive the occurrence in a favourable light, recognising it as a noteworthy advancement in improving digital skills and promoting independent study among youngsters. The utilisation of interactive electronic documents, QR codes, and diverse software tools not only facilitated the learning process but also fostered the inclination of students to make well-informed choices about the utilisation of technology, thereby bolstering their overall educational growth. Although the exercises were independent, the structure given by Blackboard (Blackboard) and the face-to-face tutoring sessions guaranteed that students received the required help and supervision throughout the process. Overall, this phase of digital integration has likely been perceived as a beneficial and enhancing experience for everyone involved.
	Stage 3: Evaluation	Using several digital tools in teaching and learning was exceptionally successful during weeks seven, eight, and nine. The achievement can be attributed to the effective integration of digital tools during the previous weeks and the different implementation levels that were followed. Using different digital resources and online applications improved the learning experience by offering interactive videos, electronic notes, and additional resources. Using QR codes to access digital resources and the methodical technique of publishing materials on Blackboard (Blackboard) facilitated efficient learning. In addition, the independent work setting and compulsory QR code scanning for attendance promoted active participation and responsibility among students. Nevertheless, several obstacles were faced. Students initially experienced discomfort and had challenges in exploring unfamiliar technological tools. Their challenges were compounded by the need to adjust to novel approaches for completing and submitting assignments, such as using scanning technology to convert their work into PDF format and subsequently uploading it. The necessity of working independently resulted in instances of exasperation and annoyance, especially for individuals who were less acquainted with the digital tools. Although provided with

		organised assistance, certain students encountered difficulties adapting to a learning environment more heavily reliant on digital integration. As a lecturer, I provided educational content and ensured students had access to appropriate technical resources. I oversaw the incorporation of several digital tools and platforms, offered ongoing support through in-person tutoring sessions, and tracked student participation and advancement using the Blackboard LMS. In addition, I devised a novel attendance system utilising QR codes and effectively dealt with student input by means of an anonymous survey, allowing me to swiftly detect and rectify any concerns. Students made a substantial contribution by actively participating in digital tools, doing projects, and offering useful feedback on their experiences. The module's success hinged on their readiness to embrace new technology and engage in self-directed learning. The utilisation of Blackboard Collaborate for collaboration during week eight, along with the valuable comments received from students, contributed to the refinement of the module and enhancement of the learning experience. Before the new level of implementation, students probably experienced a combination of enthusiasm and apprehension about the new digital tools. Throughout the event, students encountered excitement and challenges while interacting with various tools. The freedom to select and utilise these instruments may have encouraged empowerment but also led to frustration. Following the event, students likely had a feeling of achievement in acquiring proficiency with the tools and successfully finishing their projects, as well as a sense of relief in overcoming obstacles. In retrospect, students may recognise the importance of digital literacy in their education and place a high value on the skills and knowledge acquired. They will likely have a good assessment of the experience, acknowledging its significance in modernising education and fostering self-directed learning. The organised assistance offered by Blackboard and the in-person coaching sessions meant that students received essential advice throughout the process. In general, this stage of digital integration is perceived as an advantageous and enhancing experience for everyone concerned.
	Stage 4: Analysis	The three-week intervention showed me that including diverse digital technologies in the educational process can significantly improve student involvement and independence. The learning experience was enhanced by focusing on assembly and pictorial drawings, including isometric, oblique, and one-point perspective drawings. Digital tools like Visla, Renderforest, Create Studio, Doodle, TurboCad, and AI tools like ChatGPT were also utilised. This enriched the learning experience through interactive videos, electronic notes, and supplementary resources. Using QR codes to access these resources and methodically uploading information on Blackboard (Blackboard) enabled streamlined and effective learning. Although students first had difficulties navigating unfamiliar applications and adjusting to new submission methods, the autonomy afforded fostered self-directed learning and accountability. Organised assistance through face-to-face tutoring sessions and anonymous feedback facilitated prompt problem-solving and ongoing

		enhancement. In summary, this phase emphasised the significance of digital literacy and the necessity of a carefully organised, technology-integrated classroom setting to promote student autonomy and involvement.
	Stage 5: Conclusion	During weeks seven, eight, and nine of the Infusion level intervention, incorporating several digital tools into the teaching and learning process significantly improved the educational experience. The emphasis on assembly and visual drawings, such as isometric, oblique, and one-point perspective drawings, enabled pupils to immerse themselves fully in the content. The positive results encompassed heightened student involvement and empowerment achieved through independent utilisation of digital tools such as Visla, Renderforest, Create Studio, Doodle, TurboCad, and AI tools like ChatGPT. These tools enabled interactive and dynamic learning by allowing access to resources through QR codes and giving structured help through Blackboard (Blackboard). Although there were positive features, students first encountered difficulties, such as feeling uncomfortable and frustrated when using foreign technology and adapting to new means of submitting assignments, such as scanning and uploading PDFs. Working autonomously also posed challenges, especially for those less acquainted with digital technologies. Nevertheless, organised assistance through in-person tutoring sessions and timely feedback enabled students to overcome these challenges, promoting independent learning and responsibility. If this intervention were repeated, I would integrate preliminary training sessions on digital tools to alleviate early unease and incorporate more collaborative activities to achieve a harmonious blend of individual work and peer assistance. Acquiring proficiency in utilising sophisticated digital technologies and promoting digital literacy would be crucial for instructors and pupils in comparable future occurrences. In summary, the three-week intervention highlighted the significance of digital literacy and a carefully organised, technology-integrated learning setting. Although there were initial difficulties, it emphasised the advantages of promoting student independence and involvement by efficiently utilising digital tools. The current stage of digital integration has been regarded as advantageous and enhancing, highlighting the importance of a methodical approach to encourage student independence and engagement.
	Stage 6: Action plan	To effectively handle similar situations in the future, a strategic approach would involve implementing innovative actions to improve the teaching and learning process. These actions are derived from the knowledge gained during the Infusion level intervention in weeks seven, eight, and nine. 1. Introductory Workshops on Digital Literacy Arrange introductory workshops to acquaint students and educators with the digital tools they will utilise. These workshops will help students and educators feel more comfortable and confident using specific digital resources and online applications right from the start.

		2. User-friendly Digital Toolkits Create and distribute user-friendly digital toolkits with step-by-step tutorials, helpful tips, and troubleshooting guides. These toolkits can be made accessible through Blackboard (Blackboard). It would be helpful to have various resources available for each digital tool, such as video tutorials, step-by-step guides, and frequently asked questions. A user-friendly digital toolkit will offer continuous assistance and materials for students to access at any time, minimising frustration and fostering independence. 3. Learning Modules with a Balanced Approach Create learning modules that incorporate a balance of individual work and group activities. Arrange the curriculum in a way that balances individual assignments with group projects. Utilise tools such as Blackboard Collaborate to facilitate virtual collaboration sessions, allowing students to exchange ideas and provide mutual assistance. This will make it possible to balance individual freedom and peer support to create a cooperative learning atmosphere while encouraging the development of independent learning abilities. 4. Programme for Peer Mentorship Introduce a peer mentorship programme where technologically proficient students guide and support their peers. Match students skilled in using digital tools with their peers who may require extra assistance. Mentors provide valuable support and assistance in navigating challenges. Such a programme and assistance will enhance confidence and proficiency in utilising digital tools, fostering a community of learners that provides a supportive environment. 5. Learning Pathways with a Gamified Approach Implementing gamification elements in the learning process can enhance engagement and motivation. Create a system that incentivises students to complete tasks, attend workshops, and assist their peers by earning rewards. Utilise various gamification techniques such as badges and leaderboards to enhance the enjoyment and involvement in the learning process. 6. Real-Time Feedback Mechanisms Take steps to incorporate real-time feedback mechanisms by utilising digital platforms. Utilise tools such as Feedback Fruits to offer immediate feedback on assignments and quizzes. Establish regular check-ins through Blackboard to promptly address any concerns. By utilising Excel and Word, it is possible to develop an automated feedback system that automatically sends personalised feedback emails to students. Every student will be referred to by their name, and their submitted tasks will be displayed alongside their average grade. Evaluation of class attendance

		and activity will also be given. In addition, pupils will be provided with recommendations on how to enhance their academic performance. 7. Journals for Reflective Learning Encourage students to keep digital learning journals to reflect on their experiences and progress. This template offers a clear and organised format for students to record their educational experiences, including any obstacles encountered and the methods employed to overcome them. These journals are suitable for sharing with educators to gain further insights. 8. Consistent Evaluation Updates Take the time to regularly review progress and adjust the teaching method based on valuable student feedback. Plan regular meetings every two weeks to evaluate student advancement and collect input on the digital resources and techniques employed. Consider this feedback to make any necessary adjustments to the curriculum and support mechanisms. By implementing these innovative strategies, future interventions can learn from the achievements and tackle the obstacles identified during the Infusion level. This approach highlights the significance of being well-prepared, receiving support, working together, and constantly striving for improvement to create a stimulating and effective learning environment.
Transformation level At the Transformation level, lecturers encourage the innovative use of digital tools for higher-order activities. Learning is flexible and self-directed, with robust access to online resources. Students use EdTech in unconventional, seamless ways, guided by the lecturer as a mentor. Collaboration involves digital tools like text, voice, and video, with students connecting with experts and	Stage 1: Description	During weeks 10 and 11, digital tools for more advanced tasks were promoted at the Transformation level. In week 10, students were required to finish a Practical Assessment Task (PAT), a compulsory formal assessment contributing to their final module mark. Every student had to complete the PAT individually, guaranteeing that all presentations accurately reflected their original work. The main goal of the PAT was to assess four subjective content and idea areas that were not included in the examination papers. The subjects encompassed design procedures, using drawing expertise and abilities in designing, management of CAD, and creating technical drawings; the precision and tidiness of freehand, manual, and CAD drawings. Students were required to demonstrate satisfactory comprehension and mastery of Engineering Graphics and Design principles by presenting orthographic and pictorial drawings. It also evaluated proficiency and expertise in necessary EGD drawing techniques using a CAD system. The second formal assignment consisted of a module test with two questions. The initial question required pupils to employ conventional graphite and paper drawing techniques. Regarding the second question, students were required to utilise OnShape as a drawing programme. Both questions were required to conform to the SANS Drawing requirements. Students physically

peers outside the classroom for diverse experiences. Higher-order collaborative activities are emphasised. Constructive learning occurs through extensive, creative use of digital tools and resources. Lecturers facilitate complex tasks that require EdTech, encouraging students to experiment and fully utilise available resources.		submitted a printed version of Question 1 at the designated test location, while they electronically submitted a digital drawing for Question 2 through a supplied link on the Blackboard (Blackboard) Learning Management System (LMS). Week eleven served as a session for receiving comments and engaging in reflection. Students were instructed to fill out an anonymous questionnaire to ascertain their familiarity with the subject matter and identify areas where they required additional support. The questionnaire also sought to ascertain the students' proficiency in utilising digital resources and online applications, such as Microsoft Forms, QR codes, and Onshape. Students used their mobile devices to scan the QR code to gain access to and respond to the inquiry. As a lecturer, I could automatically monitor and analyse the input from students, allowing me to address any concerns or problems that may arise promptly. Learning was characterised by its adaptability and autonomy, with ample access to comprehensive internet resources. Under my guidance as a mentor, students employed EdTech in innovative and effortless ways. The collaboration encompassed the utilisation of digital resources such as text, audio, and video, enabling students to engage with professionals and peers beyond the confines of the classroom, thereby facilitating a wide range of experiences. The focus was on promoting advanced collaborative efforts. Constructive learning was facilitated by utilising digital tools and resources creatively and extensively. Tutors guided students through intricate EdTech assignments, motivating them to explore and make the most of the tools at their disposal.
	Stage 2: Feelings	The feeling was generally a combination of eagerness and enthusiasm regarding incorporating sophisticated digital tools into the curriculum. I was excited to observe how students would approach the Practical Assessment Task (PAT) and the module test, as these assignments would challenge them to apply their knowledge creatively. At the discussion of the PAT, I felt a mix of pride and anxiety. Observing students as they tackled the PAT and utilised tools like OnShape was satisfying. Nevertheless, I could not help but worry about their comfort and capacity to adapt to these unfamiliar challenges. Following the event, I experienced a feeling of satisfaction and a weight lifted off my shoulders. The students have shown a solid understanding and command of Engineering Graphics and Design principles through their orthographic and pictorial drawings. They demonstrated their skill in essential EGD drawing techniques using a CAD system. Upon contemplation, I am pleased with the students' perseverance and aptitude for surmounting initial challenges with digital tools. Their progress demonstrated their dedication and ability to adjust. I think individuals, including students, experienced various feelings throughout the event. At first, individuals may have experienced feelings of apprehension and being inundated by the unfamiliar technology and the stress of individual evaluations. They likely felt a sense of empowerment and

		accomplishment as they gained more familiarity with the tools and tasks. Reflecting on the past, it seems that others positively perceive the experience, acknowledging it as a valuable milestone in their educational path that improved their digital skills and self-reliance. In general, the incorporation of digital tools for complex tasks was a truly transformative experience. The text emphasised the significance of being adaptable and continuously learning for both students and educators. This period highlighted the importance of utilising technology to enhance advanced learning activities and cultivate a more profound comprehension of Engineering Graphics and Design principles.
	Stage 3: Evaluation	During weeks 10 and 11, using digital tools for more complex tasks at the Transformation level resulted in positive and negative outcomes. It is worth noting that the Practical Assessment Task (PAT) and the module test allowed students to showcase their comprehension and proficiency in Engineering Graphics and Design principles. The PAT assessed students' abilities in design procedures, drawing techniques, CAD management, and the creation of technical drawings. The students successfully utilised orthographic and pictorial drawings to meet the necessary standards, showcasing their dedication and the structured guidance they received. As a lecturer, my primary responsibility was to assist and guide students, ensuring they could overcome any obstacles and develop a comprehensive grasp of the subject matter. Unfortunately, there were some bumps along the way. Initially, students encountered challenges in adjusting to new technologies and becoming self-reliant. The unfamiliarity with specific tools and the frustration with new submission methods, like OnShape and Blackboard (Blackboard), presented considerable difficulties. The other obstacle was that not all students had their own laptops and were forced to work on the institution's desktops. This desktop is outdated and makes it difficult for students to work on. Slow Wi-Fi also has a considerable influence on the working of the students. Despite the challenges, the assistance offered through in-person tutoring sessions and prompt feedback assisted students in overcoming their initial difficulties, fostering self-directed learning and accountability. During week eleven, students participated in a feedback and reflection session. They were given an anonymous questionnaire to evaluate their understanding of the subject and pinpoint areas where they required extra assistance. The survey also assessed their level of proficiency in utilising digital resources and online applications such as Microsoft Forms and QR Codes. This process enabled me to efficiently monitor and analyse student input, promptly addressing any concerns or problems.

		The learning experience was marked by flexibility and independence as students creatively and seamlessly incorporated EdTech into their studies. Collaboration incorporated various digital resources, including text, audio, and video, allowing students to interact with professionals and peers outside the classroom. This experience highlighted the significance of encouraging advanced collaborative efforts and constructive learning through using digital tools. Looking back on the experience, I experienced satisfaction and unease. As I watched students engage with the PAT and navigate tools like OnShape, I couldn't help but worry about their comfort and how well they could adjust to these new and unfamiliar tasks. After the event, I was pleased and reassured by the students' strong grasp of Engineering Graphics and Design principles. I was genuinely impressed by their progress, which showed their unwavering commitment and adaptability. It made me immensely proud of their determination. Students probably went through a variety of emotions during the event. At first, individuals may have experienced some apprehension and feeling overwhelmed by unfamiliar technology and individual evaluations. As they grew more accustomed to the tools and tasks, they likely experienced a feeling of empowerment and achievement. Looking back, many people tend to see the experience positively, recognising it as an important step in their education that improved their digital skills and independence. Overall, incorporating digital tools for intricate tasks proved to be a truly revolutionary experience. It emphasised the importance of adaptability and continuous learning for students and educators, highlighting the role of technology in enhancing advanced learning activities and fostering a deeper understanding of Engineering Graphics and Design principles.
	Stage 4: Analysis	Using digital tools for more complex tasks at the Transformation level resulted in favourable and unfavourable outcomes. The Practical Assessment Task (PAT) and the module test allowed students to showcase their comprehension and skill in Engineering Graphics and Design principles. The PAT evaluated their skills in design procedures, drawing techniques, CAD management, and the development of technical drawings. Students demonstrated their commitment and received guidance to create accurate orthographic and pictorial drawings, meeting the required standards. As a lecturer, my primary responsibility was to assist and mentor students, aiding them in overcoming challenges and acquiring a thorough understanding of the subject matter. Nevertheless, the process presented its fair share of difficulties. At first, students faced challenges adapting to new technologies and developing independence. The lack of familiarity with tools such as OnShape and the Blackboard (Blackboard) Learning Management System and the challenges

		of adapting to new submission methods posed considerable obstacles. In addition, certain students faced the challenge of not having their laptops and used outdated institutional desktop computers. The slow Wi-Fi connection made this even more difficult, which further hindered their productivity. Despite the obstacles, face-to-face tutoring sessions and timely feedback supported students in overcoming their initial challenges, promoting independent learning and responsibility. During week eleven, a feedback and reflection session took place. Students were given an anonymous questionnaire to assess their comprehension of the subject and pinpoint any areas that required additional support. The survey also evaluated their familiarity with digital resources and online applications, including Microsoft Forms and QR Codes. This process allowed me to effectively monitor and analyse student input, promptly addressing concerns or problems. The learning experience was marked by a user-friendly approach and a scholarly focus as students adeptly integrated EdTech into their studies. The collaboration involved a range of digital resources, including text, audio, and video, which enabled students to engage with professionals and peers beyond the confines of the classroom. This experience emphasised the significance of promoting advanced collaborative efforts and constructive learning through digital tools. Upon reflection, I experienced a combination of contentment and apprehension. Observing students actively participate in the PAT and confidently navigating tools like OnShape was gratifying, although I was concerned about their comfort and adaptability to these unfamiliar tasks. After the event, I was impressed and encouraged by the students' solid understanding of Engineering Graphics and Design principles. Their progress showcased their dedication and flexibility, which filled me with immense pride for their perseverance. Students probably went through a variety of emotions during the event. At first, they might have experienced unease and a sense of being overwhelmed by the new technology and individual assessments. As they became more familiar with the tools and tasks, they probably experienced a sense of empowerment and achievement. Upon reflection, numerous individuals view the experience in a favourable light, acknowledging it as a significant educational milestone that improved their digital proficiency and self-reliance. Overall, integrating digital tools for intricate tasks proved to be a groundbreaking experience. The text highlights the significance of being adaptable and continuously learning for students and educators. It also emphasises the role of technology in enhancing advanced learning activities and promoting a deeper understanding of Engineering Graphics and Design principles.
	Stage 5: Conclusion	Promoting digital tools for advanced tasks at the Transformation level resulted in many valuable experiences and lessons. The Practical Assessment Task (PAT) and the module test allowed students to showcase their knowledge and abilities in Engineering Graphics and Design principles. The PAT provided a comprehensive evaluation of their skills in design procedures, drawing techniques, CAD management, and technical drawing creation. Students demonstrated their commitment and the advantages of receiving structured guidance through orthographic and

		pictorial drawings, which improved their technical skills. As an educator, I needed to continue to play a vital role in guiding and assisting the students, aiding them in overcoming challenges and achieving a deep understanding of the subject matter. Nevertheless, the event also presented some difficulties. At first, some students faced challenges adjusting to new technologies and developing independence. The lack of familiarity with tools such as OnShape and the challenges of adapting to new submission methods presented considerable obstacles. In addition, some students faced challenges accessing personal laptops and instead had to rely on outdated institutional desktops with slow Wi-Fi, adding further complexity to their work. Despite the obstacles, face-to-face tutoring sessions and timely feedback played a crucial role in assisting students in overcoming initial challenges promoting independent learning and responsibility. During the feedback and reflection session, students could assess their comprehension and pinpoint areas where they required additional support. This evaluation was conducted through an anonymous questionnaire. This process also evaluated their skill level using digital resources and online applications such as Microsoft Forms and QR Codes. The data collected allowed me to efficiently monitor and analyse student input, promptly addressing any concerns or problems. The learning experience was marked by a user-friendly approach and a scholarly atmosphere as students skilfully incorporated EdTech into their academic pursuits. This emphasised the significance of encouraging advanced collaborative efforts and constructive learning through digital tools. Looking back on the experience, I experienced a blend of contentment and unease. Witnessing students actively participating in the PAT and utilising tools like OnShape was satisfying. However, I had concerns about their ease and ability to adapt to unfamiliar tasks. After the event, I felt satisfied and confident in the students' understanding of Engineering Graphics and Design principles. I was filled with immense pride as I witnessed their unwavering commitment and adaptability, which showcased their impressive progress. Students probably had a variety of feelings throughout the event. At first, individuals may have experienced unease and feeling overwhelmed by the new technology and personal assessments. As they became more familiar with the tools and tasks, they probably experienced a sense of empowerment and achievement. Looking back, numerous students have a positive perspective on their past experiences, acknowledging them as significant educational milestones that improved their digital skills and independence.

		Overall, incorporating digital tools for intricate tasks proved to be transformative. It emphasised the significance of being adaptable and constantly learning for students and educators. In order to address technical challenges, I would prioritise improving access to modern equipment and faster Wi-Fi. In addition, it will be crucial for both students and myself to develop skills in digital tool training and time management. This period emphasised the importance of technology in enhancing advanced learning activities and promoting a deeper understanding of Engineering Graphics and Design principles.
	Stage 6: Action plan	In order to better handle similar situations in the future and promote a more dynamic and flexible learning environment, I suggest implementing the following innovative action plan: 1. Improving Digital Infrastructure and Accessibility 1.1 Creating a mobile CAD lab is made simple using portable, high-performance laptops with pre-installed CAD software such as OnShape. These labs can be easily shared among classrooms or loaned to students, guaranteeing equal access to the essential tools. 1.2 Establish dedicated Wi-Fi enhancement zones in key areas on campus to improve connectivity. Collaborate with tech companies to support these zones, guaranteeing all students' strong and dependable internet access. 2. Teaching and Support Strategies that Foster Innovation 2.1 Developing Gamified Learning Modules: Create engaging learning modules for CAD and other technical skills. These modules can transform the learning process into an engaging, competitive, and enjoyable experience, making it more accessible for students to understand complex concepts. 2.2 Peer Mentorship Programme: Implement a programme that allows experienced students or alumni to guide and support current students. This facilitates communication between individuals with varying levels of expertise and promotes a cooperative atmosphere for learning. 2.3 Real-time: Create virtual help desks with real-time chat and video support for seamless assistance. Utilise AI-powered chatbots to address simple inquiries, leaving human tutors available to tackle more intricate matters. This guarantees prompt support, no matter where or when it is needed. 3. Feedback and Reflection for Enhanced Learning

		3.1 Utilise interactive feedback tools such as Kahoot! or Padlet to enhance the engagement of the feedback process. These tools offer immediate feedback and facilitate dynamic interaction during reflection sessions. 3.2 Reflection Workshops: Arrange frequent reflection workshops where students can discuss their experiences and obstacles in small groups. Utilise design thinking techniques to assist individuals in reflecting on their learning process and pinpointing areas that can be enhanced. 4. Collaboration and Learning Across Different Disciplines 4.1 Industry Partnership Projects: Collaborate with local industries to develop practical projects for students. This provides students with hands-on experience and enhances their understanding of how their skills can be applied in real-world professional settings. 4.2 Organise interdisciplinary hackathons that encourage collaboration among students from various disciplines to tackle intricate challenges using digital tools. This promotes a culture of innovation and creativity, motivating students to utilise their knowledge in unique and inventive ways. 5. Ongoing Professional Growth 5.1 Continuous Digital Training: Offer ongoing professional development opportunities for students and educators to stay updated on the latest digital tools and technologies. We provide various educational opportunities, including workshops, online courses, and certifications, to ensure that everyone stays informed and current. 5.2 Time Management Seminars: Host seminars and workshops that emphasise practical strategies for enhancing time management and boosting productivity. Provide students with practical techniques to manage their academic workload while juggling real-world assignments and personal commitments. 6. Utilising Data and Analytics 6.1 Learning Analytics Dashboards: Create learning analytics dashboards that offer up-to-date insights into student progress and engagement. Utilise this data to identify students facing challenges and provide them with tailored assistance at an early stage.

		6.2 Predictive Analytics for Resource Allocation: Utilise predictive analytics to anticipate resource requirements such as tutoring, technical support, and equipment. This facilitates a proactive approach to managing student needs rather than a reactive one. By implementing this action plan, a learning environment that is both accessible and stimulating can be established, utilising the full capabilities of digital tools. This approach tackles the technical hurdles and fosters a culture of ongoing learning and innovation. The aim is to support students and educators in navigating the ever-evolving academic environment, enabling them to excel in Engineering Graphics and Design. The focus must be on enhancing their abilities and cultivating a profound comprehension of the subject matter. This strategy aims to enhance future experiences, making them more seamless, inclusive, and enriching for all participants.

In conclusion

Reflecting on the 10-week intervention, it became evident that using Gibbs's reflective cycle, valuable insights and potential outcomes for future digital integration initiatives were uncovered. The intervention effectively showcased the advantages of providing structured guidance to students, helping them improve their technical skills. Thorough evaluations, including the Practical Assessment Task (PAT) and module tests, achieved this. Students demonstrated their understanding and skills in Engineering Graphics and Design principles, highlighting their dedication and the benefits of incorporating EdTech.

However, the intervention also brought attention to a number of obstacles. At first, students faced challenges getting the hang of new technologies such as OnShape and adjusting to different ways of submitting their work. In addition, the students faced challenges accessing personal laptops, relying on outdated institutional desktops, and dealing with slow Wi-Fi, further complicating their work. Despite these challenges, in-person tutoring sessions and prompt feedback were instrumental in assisting students in overcoming initial obstacles fostering self-directed learning and accountability.

The feedback and reflection session, conducted via an anonymous questionnaire, enabled students to evaluate their comprehension and pinpoint areas that require further assistance. This process also assessed their ability to utilise digital resources and online applications, allowing for effective monitoring and prompt intervention.

Overall, the intervention had a profound impact, highlighting the significance of being flexible and constantly acquiring knowledge for both students and educators. In order to make progress, it will be essential to tackle technical obstacles by enhancing the availability of up-to-date equipment and faster Wi-Fi connections. In addition, honing your abilities in using digital tools and managing your time effectively will greatly improve your learning journey. The intervention highlighted the importance of technology in promoting advanced learning activities and enhancing the comprehension of Engineering Graphics and Design principles.

Appendix H: 10-Week intervention

Level of integration	Week	Lesson outcome	Type of lesson	Type of activity	Comments
Entry level Shaw et al., 2018. At the entry level, lecturers use digital technology to deliver content, while students passively receive information through videos and specific applications. The lecturer is the primary user of digital tools, and student collaboration is minimal and mainly non-digital. Constructive learning involves the lecturer providing information via digital tools, with students passively consuming it. Resources are typically textbook-like and lack real-world context, resulting in no authentic learning. The lecturer manages goal-directed learning through digital	1	Module Orientation: - Understand the overall structure and objectives of the module. - Familiarise with the key topics and expectations. - Recognise the resources available for the successful completion of the module. Blackboard Orientation: - Navigate the Blackboard learning management system efficiently - Access course materials, assignments, and announcements. - Utilise Blackboard tools for communication and collaboration. Teaching and Learning Style Orientation: - Identify various teaching and learning styles. - Adapt personal learning strategies to align with instructional methods. - Engage effectively with different teaching techniques	Face to face (F2F)	An in-depth module overview was presented to help students acquire crucial skills. Initially, students were familiar with using their smartphones to scan a document, transform it into a PDF format, and subsequently upload it onto Blackboard. In addition, they verify whether their mobile devices can scan QR codes. As a concluding evaluation, students were requested to utilise a video-making application to produce a brief 30-second video showcasing their learning environment, which they will distribute among their peers.	An instructional method was used, utilising Blackboard (Blackboard) as the Learning Management System (LMS) to communicate course material and keep track of student progression. Students were familiarised with the module and course content through a PowerPoint presentation and a guided tour of their Blackboard module course. This occurred during the first week of the semester and the contact session for the EGDC1614 module. This module will equip students with the necessary knowledge, skills, and attitudes to utilise EGD techniques effectively. The focus is on introductory Engineering, Geometrical, and Mechanical drawings in the FET phase. The meeting took place in-person at the EGD Lab. The introduction to Blackboard was facilitated through the Learning Management System (LMS), with students quickly accessing the content on their devices. Both the students and the lecturer actively participated. The lecturer offered instructional content, resources, and feedback while students engaged with the material, completed

instructions and feedback.		for optimal learning outcomes.			assignments, and actively participated in class activities.
	2	LU 1: Basic Principles of Drawing - Understand and apply the foundational principles of drawing. - Explore the essential concepts that guide effective drawing practices. LU 2: Freehand Sketches - Develop the ability to create accurate and expressive freehand sketches. - Enhance skills in observing and translating visual information onto paper. LU 6: How to Draw Digitally - Learn the techniques and tools required for digital drawing. - Gain proficiency in using digital platforms and software for artistic creation.	Face to face (F2F)	A two-hour session was held with students as the lecturer specifically addressed the course's learning outcomes. During this session, I delved into the fundamental theoretical concepts that students must grasp and master over the course. A two-hour practical session was presented by a guest lecturer on the creation of EGD drawings using PowerPoint. This hands-on demonstration taught students the essential skills to use PowerPoint as a powerful drawing tool for their assignments. A second practical session was done with them in week three. A tutor presented a 2-hour tutorial session, including a comprehensive review of the Learning Outcomes and practical instructions	As the lecturer, I provided instructional and welcome videos, created PowerPoint slides for lessons, guided students to work independently on technology-related tasks, and ensured all the necessary information was easily accessible on Blackboard. Students utilised various digital resources and online applications to complete tasks independently. They also actively engaged in class participation by scanning QR codes. Since week two, they have started to scan QR codes to register attendance and class attendance. Additionally, they could conveniently monitor their progress and attendance on Blackboard. In addition, they were provided with regular updates and evaluations of their assignments to offer guidance and feedback. As a result of these actions, a well-organised and closely supervised learning environment was established, allowing students to easily access the information they needed, complete their tasks, and receive prompt feedback. Tracking student participation and monitoring progress ensured a well-structured and organised learning experience.

				on drawing using PowerPoint. This session was designed to enhance their understanding of the subject's theory while giving their practical experience with the drawing application. Students received three tasks for their homework assignments: For Homework Drawing 1 (HD1), they were tasked to create a drawing using a pencil on a drawing sheet. This assignment requires them to submit your completed drawing in class. For homework Drawing 2 (HD2), students received an assignment they had to draw at home with a pencil on a drawing sheet. As a practical assignment, students must utilise PowerPoint as the drawing application, draw the exercise they receive from the quest lecturer and submit it through the designated link on	

				Blackboard (Blackboard). This assignment was also marked online, and feedback was given to the students.	
Adoption level (Shaw et al., 2018) At the Adoption level, lecturers control the digital technology used and guide students through projects step-by-step with the same tools. Students engage in constructive learning by conventionally using digital resources under close lecturer supervision. Collaborative learning happens through the limited use of tools like email. Authentic learning includes guided activities with real-world context, allowing students to apply technology to relevant content.	3	LU 3: Geometrical Constructions - Understand and apply basic geometric principles to construct accurate shapes and angles. - Develop proficiency in using geometrical tools such as compasses, protractors, and rulers for construction. - Analyse and solve problems involving geometric constructions in both two-dimensional and three-dimensional spaces. - Demonstrate the ability to construct bisectors, perpendiculars, and various polygons. - Integrate geometric construction skills into practical applications such as design and engineering projects. LU 4: Orthographic Projection - Comprehend the principles of orthographic projection	Theory: F2F / Hyperflex Practical: F2F Tutor: F2F	A welcome and instructional video was created using Renderforest and shared on Blackboard (Blackboard) to introduce students to the course and provide an overview of the learning activities. I presented a two-hour theory session as the lecturer on the Learning Outcomes. At the same time, a new teaching and learning method, hyperflex teaching and approach, was explained and introduced to the students. It was introduced to them that hyperflex learning is an approach which provides flexible and dynamic educational experiences. A motivational video was created using Animaker and distributed to students through Blackboard to inspire their active involvement	Effective learning was facilitated when educational content is delivered using PowerPoint slides. Students were given the task to work on technology-related assignments independently using Blackboard as the Learning Management System (LMS). Students were advised that all the information needed to successfully complete the module could be accessed on this platform. Students obtained information from the lecturer using digital resources and online applications. Weekly announcements were shared through Blackboard and automatically sent to all students via email. The module's resources, such as a study guide and study notes, were conveniently accessible through Blackboard, making it easy for students and instructors to access and utilise them. Monitoring student class participation was made efficient by implementing a system where students were required to scan a QR code at the beginning of each class. This information was then

Goal-directed learning involves the lecturer directing students in setting goals and monitoring activities using digital tools (Shaw et al., 2018).		and its importance in technical drawing and engineering. • Develop the skills to create accurate orthographic projections of three-dimensional objects onto two-dimensional planes. • Interpret and produce orthographic drawings, including front, top, and side views. • Apply orthographic projection techniques to create detailed and precise technical drawings. • Analyse complex objects and effectively represent them using orthographic projections in professional contexts. Lesson Unit 6: How to Draw Digitally • Learn the techniques and tools required for digital drawing. • Gain proficiency in using digital platforms and software for artistic creation.		and interest in the course content. The purpose of this method was to guarantee that students had a comprehensive understanding, were driven, and possessed the essential abilities and information to excel in the class. The guest lecturer presented a second two-hour workshop on creating EGD drawings using PowerPoint. The aim was to provide students with hands-on experience and practical skills in digital drawing. To strengthen the understanding of the subject matter, the course tutor presented a two-hour tutoring session that specifically targeted the Learning Outcomes and the application of drawing techniques using PowerPoint. This session aimed to provide individualised assistance and support to the students. For their assignments, students were given two	compiled into an Excel spreadsheet to provide a comprehensive summary of student participation. In addition, the well-being of students was evaluated by collecting responses to specific questions using a QR code scan. Student progress and task completion were monitored through Blackboard's tracking system, which logged the frequency and timing of students' assignment access. Students received regular updates on the module, which helped them to stay on track with their tasks and objectives. Their assignments were graded, and feedback was provided through the assignment rubric, memo, and grades uploaded on Blackboard. Weekly attendance records were conveniently uploaded on Blackboard, enabling students to effortlessly track their participation.

				tasks. The first task, HD 3, required them to draw a design using a pencil on a drawing sheet, which they then submitted in class. The second task, HD 4, involved creating a PowerPoint drawing and submitting it through a Blackboard link. As part of a research project, students completed the initial questionnaire using Google Forms. They could easily access the forms by scanning a QR code provided on Blackboard. To help them understand the process, a brief explanatory video was also made available. A comprehensive eNote page was shared with students, including all the essential links and documents for the research project. These included an information document, an Ethical Code of Conduct form, a Consent Form, and	

				Questionnaire 1. Additionally, hard copies of both forms were also made available for students to sign.	
	4		Theory: Hyperflex Practical: Hyperflex Tutor: F2F	As lecture focused on learning outcomes during the theory session and was delivered entirely through YouTube videos, supplemented with several website links to provide additional information. The two-hour practical session was highly flexible, allowing students to choose between attending in-person or joining online via a provided link. During this session, students were required to complete a drawing exercise using PowerPoint independently. The tutorial session emphasised the use of OneNote as a drawing application, with the tutor assigning a task to draw using OnShape. Additionally, students received two homework	

				assignments: HD 5 required students to draw with a pencil on a drawing sheet and submit it in class, while HD 6 involved creating a drawing using PowerPoint and submitting it through a link provided on Blackboard.	
Adaptation level (Shaw et al., 2018) At the Adaptation level, lecturers integrate digital technology into lectures, though they still decide which tools to use. Students work independently with these tools. Collaborative learning is encouraged through digital technology. Constructive learning occurs as students use digital tools to build concepts and explore their applications independently. Authentic learning begins as students	5	Module Test 1	Sit-down F2F Test:	The test consists of two questions, each focusing on different drawing methods. For the first question, students are required to use traditional drawing techniques with pencil and paper. The second question involves creating a drawing using PowerPoint as the drawing application. Both questions must comply with the SANS Drawing standards. Students did submit the hard copy of their answer	During weeks five and six of the intervention, I seamlessly integrated digital technology into my lectures, allowing students to start to choose the most effective tools. Students were motivated to engage in independent work using these tools, fostering a culture of collaborative learning through digital technology. Students could engage in constructive learning by using digital tools to develop their understanding of concepts and independently explore how they can be applied. In addition, authentic learning emerged as students actively participated in digital technology activities relevant to their lives and more significant societal concerns. I facilitated goal-directed learning by providing guidance and tools for students to set, plan, and evaluate their activities. During week 5, students engaged in independent use of digital resources and online applications, applying these tools

use digital technology in activities related to their lives and broader issues. Goal-directed learning involves the lecturer selecting tools and guiding students to set goals, plan, and evaluate activities.				to Question 1 at the test venue, while the digital drawing for Question 2 was submitted through a link provided on the Blackboard (Blackboard) LMS system.	in traditional ways to foster conceptual understanding and meaningful interaction. Class participation was monitored by having students scan a QR code at the start of each class, and their involvement was summarised in an Excel spreadsheet. Student progress and task completion were tracked using the Blackboard Learning Management System (LMS), which recorded when and how frequently students accessed their assignments. Students received guidance and feedback on the module through weekly updates about upcoming tasks and objectives. Feedback on assignments, including the rubric, memo, and grades, was uploaded to Blackboard. Weekly attendance was also recorded on Blackboard, allowing students to monitor their participation easily.
	6	LU 4: First Angle Orthographic Projection • Understand the principles and conventions of first angle orthographic projection. • Develop the ability to create accurate and detailed first angle orthographic projections. • Demonstrate the capability to interpret and analyse first	Independent work week.	Students were provided with three short videos about First Angle Orthographic drawings, created using Renderforest, CreatStudio, Doodle, and TurboCad. Additional resources included YouTube videos and relevant website addresses to further	In this independent study week, students were responsible for completing their assignments and projects on their own. The tutor offers face-to-face tutorials focused on drawing with OnShape, providing guidance and support as necessary. This format allows students to enhance their skills independently while benefitting from expert guidance during scheduled tutorial sessions.

		angle orthographic drawings. • Apply first angle orthographic projection techniques to represent three-dimensional objects in two dimensions. LU 5: Assembly Drawings Comprehend the purpose and importance of assembly drawings in engineering and manufacturing. • Gain proficiency in creating detailed assembly drawings, including depicting component relationships and assembly sequences. • Interpret and analyse assembly drawings to understand the process and component fit. • Utilise industry standards and conventions to produce clear and precise assembly drawings. • Demonstrate the ability to use online application software to create and edit assembly drawings.		support their understanding. For their assignments, students needed to complete two tasks: 1. HD 7: Draw a First Angle Orthographic drawing using a pencil on a drawing sheet and submit it in class. 2. HD 8: Create a drawing using OnShape as a drawing application and submit it via the link provided on Blackboard (Blackboard). Additionally, a questionnaire for the second-year lecturer was created using Google Forms and sent via email with the link. A video explaining the rationale behind the questionnaire was also sent to the lecturer, created using Visla. This questionnaire did aims to gather insights from another lecturer on using EdTech resources in the classroom, focusing on the technological	As students gain a deeper understanding of these tools conceptually and procedurally, the need for direct guidance from the lecturer decreases. I as lecturer assumes a facilitator role, encouraging and supporting increased student interaction with technology tools. Students independently use these tools in conventional ways to collaborate with their peers. Student progress and task completion are tracked using the Blackboard Learning Management System (LMS), which records when and how frequently students access their assignments. Feedback on assignments, including the rubric, memo, and grades, is provided on Blackboard.

				pedagogical content knowledge (TPACK) Framework. The response help to identify best practices, challenges, and opportunities for improvement in integrating EdTech resources to enhance teaching and learning for preserves students in the field of technology education.	
Infusion level level (Shaw et al., 2018) At the Infusion level, various digital tools are seamlessly integrated into teaching and freely available to students. Students actively learn by choosing and frequently using specific digital tools. Lessons support the self-directed use of technology, fostering a collaborative environment. Constructive learning	7	LU 5: Assembly Drawings - Comprehend the purpose and importance of assembly drawings in engineering and manufacturing. - Gain proficiency in creating detailed assembly drawings, including depicting component relationships and assembly sequences. - Interpret and analyse assembly drawings to understand the process and component fit. - Utilise industry standards and conventions to produce clear and precise assembly drawings. - Demonstrate the ability to use online application	Independent work week. Tutor presents f2f	This week activity incorporates various multimedia and interactive components to enhance the understanding of assembly drawings. Students had to watch two instructional videos on drawing assembly diagrams, the videos were created by using Visla and Renderforest. In addition, a PowerPoint presentation titled “JPEDG Training” was transformed into a video format using Renderforest to enhance clarity.	During weeks seven, eight, and nine of the intervention and module, various digital technologies were seamlessly integrated into the teaching and learning process. Lately, there has been a focus on topics like assembly and pictorial drawings, particularly isometric, oblique drawings, and one-point perspective. Students actively incorporate and regularly use specific digital tools to enhance their teaching and learning experience. Throughout this period, students primarily worked independently. Specialised videos and notes were made available to students on Blackboard (Blackboard) as digital resources. The tools were accessible via an interactive electronic document, which included links to videos, notes,

happens as students select tools to understand concepts. Authentic learning is enhanced with access to diverse resources, allowing the exploration of personal interests. Goal-directed learning becomes flexible as students use various tools for planning, monitoring, and evaluating their work.		software to create and edit assembly drawings.		Students were provided with study notes on the topic, which were generated by using ChatGPT to create a thorough and user-friendly e-document. A comprehensive document was created using Piktochart and Vimo, gathering all the necessary resources such as videos, notes, quizzes, and homework, providing an immersive learning experience. A digital quiz was developed using Blackboard Quiz assessment to evaluate students' comprehension of the subject matter. For practical application, students were expected to complete HD 9 by using a pencil to draw on a drawing sheet. After finishing their drawings, they had to scan and submit them as PDFs through the	quizzes, and homework assignments using QR Codes. Students employed traditional drawing methods with pencils to complete their tasks. However, they later learned how to scan and convert their drawings into PDF format using mobile devices. The assignments were scanned and then uploaded to Blackboard using the links provided in the e-document. Several software solutions were used to enhance the learning experience. I used Visla and Renderforest to create engaging videos with subtitles and explanations. Create Studio, Doodle, and TurboCad were used to create additional videos on the provided topics. Interactive electronic notes were created using AI tools like ChatGPT, while the interactive working document was built using Piktochart and Vimo. Blackboard served as the Learning Management System (LMS) for posting quizzes. During the eighth week, AI Software, Gamma, was used to create a PowerPoint presentation based on the electronic note's students received. Furthermore, students were provided with hyperlinks to YouTube videos and specific websites pertinent to the subjects.

				provided link on Blackboard.	In week nine, Feedback Fruits was used to provide the e-notes. Students were required to answer specific questions at various stages of the document before continuing with their assignments.
	8	LU 6: Pictorial views Oblique and Isometric • Accurately create and interpret both oblique and isometric pictorial views. • Demonstrate proficiency in representing three-dimensional objects on a two-dimensional plane, understanding the principles and applications of these techniques in various contexts such as technical drawings, design visualisation, and architectural renderings.	Online class – Blackboard Collaborate F2F Practical Session, Tutor presents F2F session on OnShape	During week 8, students did engage with various resources and tools to enhance their understanding of Isometric and Oblique Drawings. Initially, students watched two short instructional videos, created using Renderforest, CreatStudio, Doodle, and TurboCad, to grasp the basic concepts of these drawing techniques. A PowerPoint presentation, developed with Gamma, was provided to illustrate the key points further. Additionally, e-Notes were created using ChatGPT to generate a comprehensive e-document that consolidates all essential information. Students also received website addresses for supplementary online	Even though students could work independently, they still had the opportunity to attend in-person tutoring sessions focused on sketching with OnShape. A collaborative session was scheduled for week eight using Blackboard Collaborate. In addition, students completed an anonymous questionnaire using Microsoft Forms to share their feedback on their experiences with the module. The input provided allowed the lecturer to address issues and accurately identify areas that need improvement. As an educator, I provide instructional content, and students select appropriate technological resources. Individuals need to have the requisite knowledge and discernment to make informed decisions when utilising different digital resources and online technology. The focus of education is on student learning rather than placing all the emphasis on technological tools. Students develop a strong understanding of various digital tools, allowing them to consistently choose and use the most suitable ones.

				resources. As part of hands-on practice, they were required to draw an isometric or oblique view with a pencil on a drawing sheet (HD 10). Completed assignments should be scanned and saved as PDFs, then submitted through the provided link on Blackboard (Blackboard). For additional support, tutors will conduct face-to-face tutorials on drawing techniques using OnShape. To gather feedback, students must complete an anonymous questionnaire, accessible via a QR code and Microsoft Forms. This questionnaire addresses their feelings about the module, any challenges they have faced, and their opinions on hyperflex learning. Based on their responses, immediate feedback will be provided to students, ensuring continuous	The lectures are designed to promote student autonomy and independence by encouraging independent use of technology. Attendance for students was tracked by requiring them to scan a QR code at the start of every class. A Microsoft Excel spreadsheet offered a succinct summary of student engagement. The Blackboard LMS monitoring system was utilised to track student progress and task completion by recording the frequency and timing of students' access to their assignments. Students received regular updates on the programme, including information about upcoming activities and objectives and valuable advice and feedback. Feedback on assignments was provided by publishing the assignment rubric, memo, and grade on Blackboard. Furthermore, the weekly attendance was documented on Blackboard, offering students a user-friendly method to monitor their participation.

				improvement and support throughout the module.	
	9	LU 6: Pictorial views One-point perspective • Create and interpret one-point perspective drawings. • Demonstrate proficiency in representing three-dimensional objects on a two-dimensional plane using one-point perspective techniques. Understand the principles behind vanishing points and horizon lines and will be able to apply these concepts to produce accurate and realistic perspective drawings in various contexts, such as technical illustrations, architectural designs, and artistic renderings.	Work on Own (Self-Study)	Students engaged with multiple resources to deepen their understanding of the topic. Relevant websites were provided to give students access to additional information and resources. e-Notes on the topic were created using an AI Ebook Creator, ensuring that the content is comprehensive and accessible. A PowerPoint presentation was developed with Gamma to visually reinforce key concepts. The e-Notes was presented to students using Feedback Fruits. Throughout the e-Notes, students will encounter various questions that they must answer before proceeding, ensuring active engagement and	

				comprehension at each stage of the document.	
Transformation level (Shaw et al., 2018) At the Transformation level, lecturers encourage the innovative use of digital tools for higher-order activities. Learning is flexible and self-directed, with robust access to online resources. Students use digital technology in unconventional, seamless ways, guided by the lecturer as a mentor. Collaboration involves digital tools like text, voice, and video, with students connecting with experts and peers outside the classroom for diverse experiences. Higher-order collaborative activities are emphasised. Constructive learning occurs through extensive, creative use of digital tools	10	In this lesson activity, students will undertake Module Test 2 They also need to submit their final practical assessment task (PAT). This task was designed to evaluate their understanding and application of the concepts covered in the module. It encompasses a range of questions and tasks that require critical thinking and problem-solving skills, ensuring a comprehensive assessment of the student's knowledge and abilities in the subject matter.	Sit-down F2F Test	The test comprised two questions. The first question required students to use traditional drawing methods with pencil and paper. For the second question, students had to draw their answers using OnShape as the drawing application. Both questions adhered to the SANS Drawing standards. Students submitted the hard copy of Question 1 at the test venue, while the digital drawing for Question 2 was submitted through a link provided on the Blackboard (Blackboard) LMS system. For the PAT, students had to follow the Design Process to solve an artificial problem.	During weeks 10 and 11, digital tools for more advanced tasks were promoted at the Transformation level. In week 10, students were required to finish a Practical Assessment Task (PAT), a compulsory formal assessment contributing to their final module mark. Every student had to complete the PAT individually, guaranteeing that all presentations accurately reflected their original work. The main goal of the PAT was to assess four subjective content and idea areas that were not included in the examination papers. The subjects encompassed design procedures, using drawing expertise and abilities in designing, management of CAD, and creating technical drawings; the precision and tidiness of freehand, manual, and CAD drawings. Students were required to demonstrate satisfactory comprehension and mastery of Engineering Graphics and Design principles by presenting orthographic and pictorial drawings. It also evaluated proficiency and expertise in necessary EGD drawing techniques using a CAD system. The second formal assignment consisted of a module test with two questions. The initial question required pupils to employ conventional graphite and paper drawing techniques.

and resources. Lecturers facilitate complex tasks that require digital technology, encouraging students to experiment and fully utilise available resources (Shaw et al., 2018).				They were expected to design a solution and create several drawings using traditional drawing methods and any digital drawing application they chose. A printed portfolio was handed in. Students could use any digital technology to support their research and compile their portfolios.	Regarding the second question, students were required to utilise OnShape as a drawing programme. Both questions were required to conform to the SANS Drawing requirements. Students physically submitted a printed version of Question 1 at the designated test location, while they electronically submitted a digital drawing for Question 2 through a supplied link on the Blackboard (Blackboard) Learning Management System (LMS). Week eleven served as a session for receiving comments and engaging in reflection. Students were instructed to fill out an anonymous questionnaire to ascertain their familiarity with the subject matter and identify areas where they required additional support. The questionnaire also sought to ascertain the students' proficiency in utilising digital resources and online applications, such as Microsoft Forms, QR codes, and Onshape. Students used their mobile devices to scan the QR code to gain access to and respond to the inquiry. As a lecturer, I could automatically monitor and analyse the input from students, allowing me to address any concerns or problems that arose promptly. Learning was characterised by its adaptability and autonomy, with ample access to comprehensive internet resources. Under my guidance as a mentor, students employed digital technology in innovative and effortless ways. The collaboration encompassed
		Students were able to discuss and interpret feedback on their assessments and understand their module marks. They reflected on their performance, identified strengths and areas for improvement, and engaged in constructive dialogue to enhance their learning experience and outcomes.	F2F	Students were asked to complete Questionnaire 2 of the Research Project using Google Forms, which was accessed through a QR code link provided on Blackboard. A short video explaining the rationale of the questionnaire was created and shown to the students. A motivational video created with Animaker was also sent to the students via Blackboard	

				to encourage attendance at this session. Feedback was given on various problems identified during the activity.	the utilisation of digital resources such as text, audio, and video, enabling students to engage with professionals and peers beyond the confines of the classroom, thereby facilitating a wide range of experiences. The focus was on promoting advanced collaborative efforts. Constructive learning was facilitated by utilising digital tools and resources creatively and extensively. Tutors guided students through intricate digital technology assignments, motivating them to explore and make the most of the ols at their disposal.

Appendix I: Curriculum for Bachelor of Education in Senior and Further Education and Training Phase: Specialising in Technology and Engineering Graphics and Design

CURRICULUM

BACHELOR OF EDUCATION IN SENIOR AND FET PHASE – YEAR 1				
Specialising in Engineering Graphics and Design and Technology Education				
SEMESTER 1				
MODULE CODE	DESCRIPTION	NQF LEVEL	CREDITS	PREREQUISITES
EGDC1614	Engineering Graphics 1.1	6	16	Engineering and Graphics Design at NSC level 4 (50%)
TEGC1614	Technology Education	6	16	
LLST1513	Lifelong Learning Skills	5	12	
EDUB1613	Education Studies 1.1: The Individual in the Learning Context	6	12	
TPRV1502	Teaching Practice 1	5	8	
			64	
UFSS1504	Undergraduate core curriculum	5	(16)	
EALT1508	English Academic Literacy for Education	5	(32)	NBT requirements not met
or AGAE1508	Academic Literacy in Afrikaans			
SEMESTER 2				
MODULE CODE	DESCRIPTION	NQF LEVEL	CREDITS	PREREQUISITES
EGDC1624	Engineering Graphics and Design 1.2	6	16	EGDC1614
TEGC1624	Technology Education	6	16	TEGC1614
EDUB1623	Education Studies 1.2 What it means to educate: Theoretical perspectives and their significance in SA education	6	12	
GPEV1623	General Pedagogy 1: Managing the Curriculum	6	12	
			56	
TOTAL CREDITS FOR YEAR 1			120	

(https://apps.ufs.ac.za/dl/yearbooks/408_yearbook_eng.pdf)

Module Description

EGDC1614						
Credits	Theory	Graphical	Practical	Tutoring	Module description	Module outcomes
16	2x Period per week	2x Period per week	2x Periods per week	2x Periods per week	This module introduces the foundational principles of Engineering Graphics and Design, encompassing essential skills such as freehand sketching, precise geometrical constructions, and the use of scales. Students will learn First Angle Orthographic Projection techniques, including bolts, nuts, and simple industrial parts, as well as the creation of detailed assembly drawings. The course also covers various pictorial drawing methods such as oblique, isometric, and one-point perspective. Additionally, students will explore descriptive geometry to determine true lengths, angles, shapes, and point views. The module concludes with an introduction to digital drawing tools, including PowerPoint and OnShape.	EGDC1614 aims to provide you with knowledge, skills, and attitudes to demonstrate, identify and apply skills and techniques in EGD regarding introductory Engineering, Geometrical and Mechanical drawings in the FET phase.

Curriculum Layout

First Semester	
Learning Unit	Description
Learning Unit 1:	Basic Principles in Engineering Graphics and Design
Learning Unit 2:	Freehand Sketches in Engineering Graphics and Design

Learning unit 3:	Geometrical Constructions in Engineering Graphics and Design: • Division of line segments: equal parts, ratios, etc. • Construction of geometrical figures from given data-parallel lines, bisecting, triangles, polygons, rhombus, parallelogram, trapezium • Scales and application: line scales, diagonal scales • Enlarging and reducing equivalent areas.
Learning unit 4:	First Angle Orthographic Projection Engineering Graphics and Design • Bolts and nuts + Castings and machine parts of simple objects from industry
Learning Unit 5	Assembly drawings in Engineering Graphics and Design • How to draw assembly drawings • Castings and machine parts of general objects from industry
Learning unit 6:	Pictorial drawings in Engineering Graphics and Design: • Oblique • Isometric • One-point perspective
Learning unit 7:	Descriptive Geometry in Engineering Graphics and Design • True lengths • True angles • True shapes • Point views
Learning Unit 8:	Digital Drawing: • PowerPoint • Introduction to OnShape

Assessment Plans

	Semester 1		
Module	Assignments 30%	Practical + Class Attendance 20%	Theory 50%
EGDC1614	10x Drawings	1x PAT	2x Module Test 3x Quiz

Graduate Attributes

Critical thinking			Problem-solving			Written communication		Ethical reasoning		Entrepreneurial mindset			
Explanation of issues	Evidence	Influence of context and assumptions	Identify, define and comprehend the problem	Identify strategies	Propose solutions/hypotheses	Sources and evidence	Language and grammar	Ethical self-awareness	Understanding different ethical	Creativity and innovation	Opportunity recognition	Initiative	Collaboration
3	4	3	3	2	2	2	3	2	2	3	3	3	3

Appendix J: Turnitin report

Final Turnit in_3 12 2024.docx

by Sybrand Coetzee

Submission date: 03-Dec-2024 10:29AM (UTC+0200)

Submission ID: 2534711130

File name: Final_Turnit_in_3_12_2024.docx (1.85M)

Word count: 71515

Character count: 444917

ORIGINALITY REPORT

8 %	5 %	5 %	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	"Proceedings of the International Conference on Advancing and Redesigning Education 2023", Springer Science and Business Media LLC, 2024 Publication	1 %
2	pdfcoffee.com Internet Source	< 1 %
3	livrepository.liverpool.ac.uk Internet Source	< 1 %
4	ebin.pub Internet Source	< 1 %
5	hdl.handle.net Internet Source	< 1 %
6	scholar.ufs.ac.za Internet Source	< 1 %
7	Barton, Melvina L.. "Exploring the Integration of Technology in Elementary Literacy Instruction: A Qualitative Descriptive Study", Nova Southeastern University, 2024 Publication	< 1 %