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Digital Technology Integration in Engineering Graphics Design Instructional Practices: A case of One South African University

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Abstract. The advent of digital technology has instigated numerous modifications in the educational scene, especially in Engineering Graphics Design (EGD) instruction and learning. This study aimed to investigate the implementation of digital technology in EGD educational methods. To accomplish this purpose, the study investigated how digital technologies are integrated into EGD instructional strategies, identifying specific digital tools or software used to improve EGD teaching and outlining how these digital tools contribute to the learning process. Qualitative data was collected by conducting face-to-face semi-structured interviews with four EGD lecturers at a specific South African university. The gathered data underwent thematic analysis, utilising qualitative data analysis which found patterns, subjects, and categories through iterative code development. The study found that basic technology devices such as cell phones, laptop computers, photocopiers, and numerous other software are only half utilised. The research also found that these digital tools are primarily employed for information sharing rather than for interactive purposes, with lecturers citing inadequate infrastructure, low network coverage, and socioeconomic factors. The study suggests that educational institutions should; make investments in technological infrastructure, offer lecturers focused professional development, and guarantee access to essential digital tools to fully benefit from digital technology in EGD learning and teaching. By addressing these issues, instructors can successfully use digital resources to improve the students' technical proficiency, conceptual comprehension, and spatial visualisation.

Keywords: Digital technology; Engineering Graphics and Design; integration; instructional process

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1. Introduction

The educational sector has undergone a multitude of transformations in recent years, particularly around Engineering Graphics and Design (EGD) instruction, because of the rapid advancement of digital technology. Following this, the pedagogical style employed to instruct EGD in various South African Higher Education Institutions (HEIs), as observed by the researchers during their tenure teaching the module, is a hybrid method of instruction and learning. Moreover, the implementation of hybrid learning by HEIs enhances the utilisation of digital technology and establishes a novel paradigm of Pedagogical Content Knowledge (PCK) practices, especially within the EGD module (Muhuro & Kangethe, 2021; Vaughan et al., 2023; Rahimi & Oh, 2024). As a result, expertise with digital applications (apps) for teaching, assessing, and learning is essential (Abduvakhidov et al., 2021).

There is an increasing consensus supporting this perspective (Cachia et al., 2021; König et al., 2020) as online instruction has accelerated the adoption of digital technology, prompting questions about the process, nature, extent, and effectiveness of digitalisation in educational institutions. Bera (2024) indicates that novel paradigm shifts in instructional delivery are arising through ideas such as but not limited to e-learning, m-learning, Computer Aided Instruction (CAI), instructional software packages, and computer-aided training. Based on this literature, EGD lecturers may need the necessary skills and resources to integrate technology innovatively when teaching subjects such as orthographic projection, solid geometry, assembly drawing, isometric drawing, and perspective drawings. As a result, this study sought to evaluate and describe the current state of technology integration in the EGD instructional process. To fulfil this aim, the researchers addressed the study's objectives, which are stated in the following section.

1.1 Objectives of the study

The primary research objective of this study was to assess and describe the existing state of technology integration in the EGD educational process. To achieve this goal, the researchers focused on investigating how digital technologies are integrated into EGD instructional strategies; identifying specific digital tools or software used to improve EGD teaching; and describing how these digital tools contribute to the instructional process.

2. Literature Review

2.1 Digital technologies integration in EGD instructional strategies

Literature demonstrates that the integration of digital technologies has become integral to contemporary learning environments, both in educational institutions and in the workplace (Sjöberg & Holmgren, 2021). However, Abedi (2024) highlights significant pedagogical challenges impeding the effective adoption of instructional technology among stakeholders. In alignment, Adarkwah (2021) observes that educators across disciplines and educational levels encounter persistent difficulties adapting to rapidly evolving technological tools within their teaching practices. The shift toward online instruction has further accelerated the adoption of digital technologies, simultaneously raising critical inquiries

regarding the scope, nature, methods, and effectiveness of digitalisation in educational settings (Cachia et al., 2021). The successful integration of digital technology as emphasised by Sackstein et al. (2022), necessitates a solid grounding in pedagogical theory, particularly in the selection and application of appropriate technological tools within classroom activities. This is especially pertinent for technical disciplines such as EGD, where fostering students' spatial visualisation skills is paramount.

Although digital technologies offer substantial instructional benefits, educators must also navigate the complexities associated with designing and implementing online communities and synchronous communication platforms (Vaughan et al., 2023). Thus, literature underscores the necessity for EGD educators to exercise informed judgment in selecting instructional strategies that address the students' diverse learning needs. Notably, there remains a gap in the literature regarding detailed practical guidelines for the effective implementation of these concepts.

2.2 Specific digital tools or software used to enhance EGD instruction

Recent scholarship demonstrates that a diverse range of advanced technologies including artificial intelligence, augmented reality, virtual reality, blockchain, and specialised software applications are being increasingly integrated into teaching and learning environments (Gaol & Prasolova, 2022). In response to this broadening technological landscape, Matsieli and Mutula (2024) advocates for higher education institutions and stakeholders to continue investing in essential digital equipment such as projectors, laptops, printers, televisions, radios, and smartphones to ensure comprehensive access to digital learning tools.

The rapid advancement of technology, particularly the proliferation of computers, mobile devices, and internet connectivity, has profoundly influenced organisational knowledge, individual expertise, and operational processes (Rahimi & Oh, 2024). In the context of EGD, Hu and Zhan (2024). highlights the educational advantages of employing 3D Computer Aided Design (CAD) software to create orthographic models, allowing for the realistic and intuitive visualisation of objects and their projections. Empirical evidence further suggests that Virtual Reality (VR) software enhances modelling proficiency by providing a more intuitive and efficient learning experience compared to traditional desktop-based CAD applications (Fang & Kao, 2023). The use of 3D visualisation in these technologies not only accelerates the learning process but also deepens the students' spatial perception and understanding of complex surface structures (Korkut & Surer, 2023).

Despite these pedagogical advancements, access to digital tools remains uneven across educational institutions. Persistent challenges related to infrastructure, funding, and resource allocation continue to impede the widespread adoption of such technologies (Alenezi, 2023). For example, while digital technology is now deeply embedded in university teaching, evidenced by the routine use of learning management systems, word processing software, communication platforms like Microsoft Teams, and multimedia resources such as YouTube and Wikipedia (Turnbull et al., 2023), there remains a pressing need to address the disparities in

digital literacy, technological infrastructure, and accessibility to promote equitable learning opportunities (Wang & Si, 2024; Sá & Serpa, 2020).

Particularly in contexts such as South Africa, infrastructural deficits, limited connectivity, and insufficient professional development are significant obstacles to effective technology integration in education (Ramoroka, 2021). Furthermore, as these digital tools often entail substantial costs and ongoing maintenance, socioeconomic disparities and underdevelopment in some regions further exacerbate the digital divide, influencing the degree and efficacy of technology adoption within and across institutions. While literature demonstrates the transformative potential of digital technologies for enhancing EGD teaching and learning, it also underscores the critical importance of sustained investment in infrastructure, targeted professional development, and policy measures that address issues of access and equity.

2.3 Contribution made by digital tools to the EGD instructional process

The integration of Information and Communication Technologies (ICT) has fundamentally transformed education, reshaping instructional practices and student learning experiences (Abbas et al., 2024). ICT adoption has enabled effective coordination and the scheduling of classes, providing students with greater access to instructional resources and learning opportunities that foster skill development. Within EGD, the implementation of CAD software has facilitated a shift from traditional manual drawing methods to advanced visualisation techniques, thereby enhancing the students' spatial abilities and technical competencies (Ndlela et al., 2026). Digital technologies have also significantly influenced the students' academic performance, cognitive development, and creative expression, while affording instructors the means to apply contemporary pedagogical approaches aligned with Education 4.0 principles (Sharlovych et al., 2023).

Empirical research demonstrates that digital technologies in technical education can increase student engagement, promote collaborative learning, and provide more dynamic avenues for teaching complex concepts (Smith, 2026). Recent advancements such as blockchain, augmented reality, virtual reality, artificial intelligence, and innovative software applications, have further expanded the possibilities for enhancing teaching and learning processes (Gaol & Prasolova, 2022). Notably, the development of specialised libraries, tools, and devices has enabled the use of virtual reality for improved data manipulation and analysis in immersive 3D environments.

Despite these benefits, persistent challenges remain, particularly regarding infrastructure and access. Many academic institutions lack adequate wireless network infrastructure, leading to dissatisfaction among both staff and students due to unreliable internet connections and limited support for online Learning Management Systems (LMS) (Maphalala & Adigun, 2021; Bryan, 2020). Nevertheless, digital technologies continue to facilitate learning as a routine practice across various contexts, including the workplace (Sjöberg & Holmgren, 2021). Lecturers are increasingly focused on maintaining student engagement and

incorporating interactive elements into their lessons to improve pedagogy (Abubakar et al., 2024), and the students with reliable access to digital resources are more likely to achieve academic success.

Furthermore, there is consensus that digital technologies contribute to the development of the students' professional competencies, particularly in relation to spatial thinking (Rakhimov & Tairova, 2021). The cultivation of spatial imagination is essential in EGD, as it enables students to comprehend and address the diverse challenges presented throughout the curriculum. However, Mtshali (2020) points out that the most significant barriers to effective practical skills instruction in technical disciplines are the educators' limited subject-matter expertise and insufficient access to instructional tools, including digital technologies.

Added to this, some scholars argue that institutions struggle to keep pace with the needs of increasingly "digitally native" students and the disruptive nature of emerging technologies (Sukra, 2023; Matsieli & Mutula, 2024). This underscores the importance of equipping educators with innovative strategies to leverage the capabilities of tech-savvy pre-service teachers, which can be achieved through targeted staff development programs. Agárdi and Alt (2024) describe the "X generation" as a cohort with advanced technological proficiency, having both witnessed and contributed to significant milestones in technological advancement, such as the advent of personal computers and the internet.

Successful digital technology integration has also been shown to enhance motivation and engagement among learners (Mhlongo et al., 2023). In educational environments, motivated students are more likely to; participate actively, collaborate with peers, and remain attentive during instruction. Matsieli and Mutula (2024) further argue that digital technologies transform education from a passive, individual activity into a collaborative process involving students, educators, and institutional stakeholders. Collectively, the literature affirms that digital technologies support students in selecting effective instructional modes and maintaining focus on learning objectives. Accordingly, this study sought to examine and contextualise the contributions of technology integration within EGD instruction.

2.4 Theoretical framework

This research was guided by the Technological Pedagogical Content Knowledge (TPACK) theoretical framework. The theoretical framework is an instructional paradigm that depicts the intersections of technology, instructional technique, and content to enable the compelling integration of technology into education. Mishra and Koehler (2006) created TPACK because there were no sufficient theories to explain or direct the successful integration of digital technologies in the classroom (De Rossi & Trevisan, 2018). TPACK gained popularity in the early 2000s, with numerous scholars' works (Graham, 2011; Mishra & Koehler, 2006) attempting to justify the extension of the PCK framework to include technology. According to Mishra and Koehler (2006), for successfully integrating technology into instruction, the TPACK framework is a paradigm for education that explains

the points where pedagogy and content must be cornerstones of any successful digital technology integration by distinguishing between these three categories of knowledge. Mishra and Koehler's (2006) TPACK framework (see Figure 1 below), which emphasises Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), according to De Rossi and Trevisan (2018), provides a useful solution to many of the problems that lecturers encounter when integrating educational technology in classrooms.

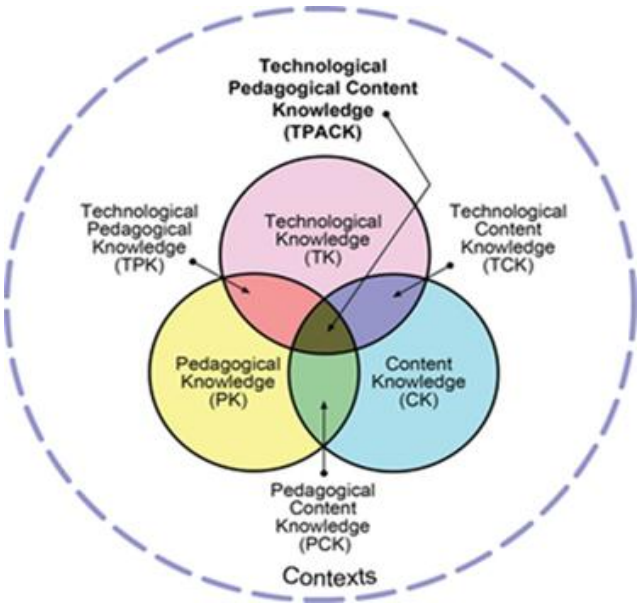

Figure 1: TPACK framework

Within the TPCK framework, the three categories of knowledge: TK, PK, and CK are integrated and recombined in different ways. Technology Pedagogical Knowledge (TPK) highlights the connection between technological instruments and instructional strategies, stressing the significance of comprehending, selecting, applying, and putting into practice effective pedagogical techniques for technology use. The TPK application was pertinent to the study since it focuses on the lecturers' understanding of selecting digital technology resources for instructional tactics. This component allowed the researcher to assess how the understanding of technology supports the instructors' choice of technology equipment and utilisation in EGD benefits teaching and learning.

Pedagogical Content Knowledge (PCK) involves understanding instructional techniques, content structure, concepts, strategies, learning difficulties, students' prior knowledge, and epistemological theories essential for effective teaching. Lastly, Technological Content Knowledge (TCK) is the understanding of the reciprocal connection between technology and content, and this means that teachers ought to comprehend how technology can be used to facilitate the subjects they teach. The study focused on technology integration in teaching methods in EGD, hence TPK was the sole component of the TPCK theoretical framework used.

3. Methodology

This research study is based on the interpretivism paradigm which allows the researcher to gain better knowledge of the phenomena and its complexity in context. As a result, the interpretivism paradigm frequently employs a relativist ontology, in which a single phenomenon may have multiple interpretations rather than a fact defined by measurement (Creswell & Tashakkori, 2007); thus, the lecturers' integration of digital technology into the EGD instructional process was investigated to gain a better understanding of its occurrence.

In addition, this study adopted a qualitative research approach. Given the size and composition of the sample and targeted population, this approach was chosen. According to Denzin and Lincoln (2011), qualitative research employs a constructivist approach to reality, allowing for a variety of interpretations of individual experiences. Furthermore, qualitative research examines the lives of people, communities, societies, and organisations through close or extended interaction in a realistic environment (Miles et al., 2014). To acquire a deeper knowledge of the context and the participants through interviews, a qualitative method was considered suitable. This made it easier for the researchers to come to concrete conclusions regarding the subject under study because it gave them more time to investigate and understand the phenomenon.

3.1 Research Design

A case study research design was used in this investigation. Creswell (2014) states that the plan or proposal in which research will be carried out is referred to as the research design. As such, it encompasses the convergence of philosophical ideas, investigative techniques, and particular approaches. Furthermore, to investigate and obtain comprehensive knowledge of the participants' perceptions, a case study research design was chosen for this study. An in-depth analysis of one unit to understand a larger set of units is called a case study (Gerring, 2004). The technical education teacher training program at the selected South African university includes an EGD component. The case study design was employed by the researchers because, as Muzari et al. (2022) have stated, it is an exploratory study that enables the researcher to interact directly with the participants and confines the study to a small sample that is thoroughly investigated.

3.2 Population and sampling

According to Majid (2018), the research population of interest is a study's intended target demographic. The population of interest for this study consisted of one South African university that offers technical education, including the EGD module. The researchers chose this HEI as a population because it offers technical education programs that include an EGD module. Sampling is a subset of a population that represents the complete population (Majid, 2018). According to Muzari et al. (2022), sampling is essential in qualitative research since it allows researchers to select a well-informed group for a study. This study identified four EGD lecturers using non-probability and selective sampling. The study employed purposive sampling to select four instructors, anticipating that they would yield comprehensive and substantial data. The participants were chosen based on their expertise of the EGD module, age, and teaching experience, as well as their

alignment with the study's goals and setting. Purposive sampling is most appropriate when the researcher has a thorough awareness of the participants' characteristics (Lune & Berg, 2017). The institution was conveniently chosen since it provides EGD throughout its vocational education program and it was financially favourable due to the researchers' proximity to the institution.

3.3 Data Collection Instruments

The authors conducted semi-structured interviews with EGD lecturers to learn about their perspectives on digital technology integration in EGD training. Ahlin (2019) asserts that semi-structured interviews offer possibilities for those involved to explore a variety of issues in greater detail and they consist of a sequence of open-ended questions based on the topic areas the researcher would like to cover. The purpose of the interviews was to understand more about their perspectives, methods, problems, and experiences in using digital tools for EGD instruction. The interviews were transcribed verbatim from audio recordings, with participants identified as "L1", "L2", "L3", and "L4".

A 35-minute interview was carried out in the researchers' workplace and over Microsoft Teams for each participant. With the permission of the research participants, an audio recorder was used to record the interview responses, which were subsequently transcribed. Prior to data transcription, rewinding and repeated listening were done. Each transcript was matched to the source's (the participating lecturer's) identification code, which was assigned to each of the lecturers that participated in the study. The coded and transcribed texts were classified using the themes derived from important concepts. The themes were checked against the data and improved accordingly. To assure the study's rigour, peer debriefing was conducted to improve credibility, alternative perspectives, and to uncover blind spots.

Table 1: Biographical data of the participants

Biographical Data of the Participants				
Participants	**Gender**	**Educational level**	**Teaching experience**	**Module specific technological training**
L1	Male	Doctor of Philosophy	21 years	Partial
L2	Female	Master of Education	26 years	Partial
L3	Male	Honours	17 years	Partial
L4	Male	Master of Education	12 years	Partial

As can be seen from Table 1, all the four participants had extensive teaching experience but lacked specific training in technology development. With two male lectures and two female lecturers, the participants were evenly distributed. There was no big difference in the attainment of specific technological advancement between both genders.

3.4 Data Analysis

According to Morgan (2022), qualitative data analysis is the act of adding structure, meaning, and order to a large amount of data. The author goes on to discuss how it is used to analyse and reveal overt and covert themes and patterns hidden in each text. The interviews were analysed using thematic analysis, which involved identifying prospective interview themes and establishing initial codes. The findings were presented and discussed in accordance with defined themes, and the lecturers were interviewed in person at certain times to meet their availability at the researchers' office.

The study followed strict ethical guidelines. The participants' confidentiality and privacy were maintained throughout the study, with names and other identifying information removed from the direct quotations (Creswell, 2014). The participants were provided with comprehensive information about the study's objectives and procedures to ensure informed participation. The relevant institutional review committee provided ethical approval, demonstrating a commitment to ethical research techniques. According to Stewart et al. (2017), trustworthiness in research refers to the overall credibility, integrity, and reliability of the study methodology and the results. Hence, this study's methodology and results adapted all the characteristics of trustworthiness.

3.5 Ethical Considerations

To address the ethical issues during the research process, informed consent was obtained, information was kept anonymous, and academic integrity standards were upheld. The ethics committee of the institution approved the dissertation from which the paper was derived. The study received no special funding and contained no conflicts of interest.

4. Results and Findings

The study sought to determine how the lecturers at one higher education institution integrate digital resources into their EGD teaching methods. The four lecturers were interviewed in person using the study techniques described above. The four lecturers' data was analysed to identify themes based on the research topics. Table 2 summarises the three themes that arose from the lecturers' comments.

Table 2: Themes and codes

Themes and codes that emerged from the responses on the integration of digital technologies into the instructional processes used in EGD					
Themes	**Codes**	**L1**	**L2**	**L3**	**L4**
Pedagogical approaches	Digital learning platforms, online collaboration, social media for learning, project-based digital instruction, discovery, and independent learning.	✓	✓	✓	✓
Enabling technologies	Microsoft Teams, Moodle, WhatsApp, AutoCAD, YouTube, PowerPoint, digital projectors, YouTube, and videos for demonstration.	✓	✓	✓	✓
Instructional impact and constraints	Flexibility and engagement, collaboration and feedback, conceptual clarity through multimedia, efficient resource distribution, practical learning limitations (limited access to CAD software, and library limitations)	✓	✓	✓	✓

The above themes surfaced from the in-person interviews with the EGD lecturers concerning their comments pertaining to the ways in which they incorporate digital technology into their instructional practices. Various answers to the question of how they incorporate digital technology into their EGD methods of instruction led to the creation of Theme 1. In the lecturers' comments, the utilisation of digital learning tools (software) became a dominant theme.

4.1 Theme 1: Pedagogical approaches

The lecturers were asked to describe how digital technologies were integrated into their instructional strategies in EGD.

In this context, the subsequent responses from the interviews are presented thus:
L1 said:

> *"I use digital resources and online tools for flexible learning and designing diagrams". The participant added, "I use social media platforms for inspiration and facilitate projects using Microsoft Teams for collaborative work and constructive feedback".*

L2 echoed the same sentiments and said,

> *"I currently use digital platforms such as Moodley, Microsoft Teams, WhatsApp, and AutoCAD; however, access to the software is restricted and there are problems with connectivity in terms of network coverage".*

L3 said,

> *"I use PowerPoint presentations, Moodle's LMS, YouTube, and CAD software to teach orthographic projection and isometric drawing, but there is lack of interactive platform for EGD when I want to monitor their progress online".*

The lecturer added that,

> *"I use a document camera, digital projector, Moodle for assignment distribution, and YouTube for real-world examples, but I must say that I do not know if I'm using these properly for EGD since I lack training on EGD technology infusion".*

In a more similar approach, L4 said,

> *"I use videos embedded on Moodle LMS, power point slide during my teaching, CAD for projects, and WhatsApp for sharing media for learning, collaborations and communication purposes".*

The findings reveal that EGD lecturers employ a range of digital technologies to support flexible learning, collaboration, and project-based instruction. The most utilised platforms included Microsoft Teams and Moodle, which served as central tools for sharing resources, facilitating collaborative work, and managing assignments. In addition, the lecturers supplemented their teaching with multimedia resources such as PowerPoint presentations, YouTube videos, and CAD software to enhance the students' spatial visualisation and engagement with complex concepts. These findings are supported by Hu and Zhan (2024) who highlights the educational advantages of employing 3D CAD software to create orthographic models, allowing for the realistic and intuitive visualisation of objects and their projections. WhatsApp was also used as an informal channel for quick communication and for the sharing of media related to coursework.

Despite these efforts, the lecturers faced notable challenges, including restricted access to certain software (such as AutoCAD), inadequate training on effective technology integration, and persistent connectivity issues stemming from limited network infrastructure. These constraints align with the broader findings in the literature, which highlight that infrastructure and professional development remain significant barriers to the full realisation of digital technology's potential in technical education (Maphalala & Adigun, 2021).

In the same vein, Ramoroka (2021) as Kgosi et al., (2023) note that in situations such as South African HEIs, infrastructural deficiencies, inadequate connectivity, and insufficient professional development pose substantial barriers to the efficient integration of technology in education. The findings indicate that while diverse digital tools are incorporated into EGD instruction to promote discovery and self-directed learning, there is a clear need for targeted professional development to equip lecturers with practical skills for effective technology use in this context.

4.2 Theme 2: Enabling technologies

The lecturers were asked about the specific digital tools or software they used to enhance teaching and learning in EGD.

The following are the extracts of their responses:

L1 said,

> *"I use Microsoft Teams for my lectures, online learning management system tools like Moodle, and social media for collaboration and communication purposes". L2 said, "I currently use Moodle and there is Microsoft teams and to add on these, I sometimes use WhatsApp to share quick information with students".* He went on to say, *"Auto CAD is an available platform, however, access to the software is very limited since I require reskilling for the modern proper use".*

On the other hand, L3 said,

> *"I basically use AutoCAD software to present 2D and 3D modelling, PowerPoint with videos and images during lectures, YouTube, digital projectors, and Moodle LMS, however, I encounter challenges when it comes to assessment because I was not trained on how to access EGD as a practical module through technology".*

Furthermore, L4 said,

> *"I use Moodle, WhatsApp, and video-based resources in my EGD lectures".*

The findings demonstrate that the EGD lecturers predominantly relied on Moodle as the principal learning management system for material distribution and student engagement, which is consistent with the broader trends in higher education (Turnbull et al., 2023). Microsoft Teams was frequently used to facilitate collaborative, project-based learning, while WhatsApp served as an efficient, informal channel for rapid communication and updates (Sjöberg & Holmgren, 2021).

AutoCAD remained essential for delivering technical drawing instruction in EGD, but restricted access and insufficient training were notable barriers, thereby echoing the findings by Bryan (2020) as well as Maphalala and Adigun (2021), who highlight software limitations and the need for ongoing professional development. Multimedia resources such as PowerPoint, YouTube, and digital projectors were also leveraged to enhance student engagement and deepen conceptual understanding (Smith, 2026; Sharlovych et al., 2023). These findings underscore the importance of both digital tool availability and lecturer competence in optimising technology integration in EGD instruction.

4.3 Theme 3: Instructional impact and constraints

The lecturers were asked how the digital tools contribute to EGD instructional process.

The following extracts were from the lecturers:

L1 said,

> "*Digital tools enhance flexibility and student engagement, facilitate collaboration, and improve assessment tasks as the level of proficiency is improved but issues with student gadgets, data and poor network reception and infrastructure remain a stumbling block".*

On the other hand, L2 said,

> *"For me, digital technologies provide communication efficiency, resource sharing, and enhances digital drawing capabilities (AutoCAD), as well as immediate feedback for my EGD student".*

L3 expressed his satisfaction by saying,

> *"Digital technologies improve conceptual understanding using multimedia, support assignment distribution, and links lessons to real-*

> *world applications building on spatial visualisation in EGD complex chapters".*

However, L3 also articulated that module specialised development programs would assist them with proficiency in teaching using technology in EGD.

L4 said,

> *"Technology integration in my case promotes versatility, independent learning and content accessibility but I face challenges in interactivity for practical components and inadequate equipment, and infrastructure hinders seamless teaching processes".*

The findings reveal that digital tools play a crucial role in EGD instruction by enhancing student engagement, collaboration, and communication efficiency. The lecturers identified tools such as AutoCAD, multimedia platforms (e.g., PowerPoint, YouTube), and learning management systems as instrumental in facilitating resource sharing, digital drawing, and linking lessons to real-world applications, thereby deepening conceptual understanding, and supporting independent learning. However, persistent challenges remain, including limited access to digital devices, insufficient infrastructure and equipment, unreliable internet connectivity, and a lack of interactivity in practical components.

These constraints not only impede the seamless integration of digital technology but also restrict hands-on learning opportunities. The study underscored the need for targeted professional development programs to improve the lecturers' proficiency in digital technology integration and addressing these barriers (Maphalala & Adigun, 2021; Mtshali, 2020; Ramoroka, 2021; Sharlovych et al., 2023). These findings are consistent with the broader literature in this paper, which highlights the transformative potential of digital technology for EGD while emphasising the critical importance of adequate infrastructure, access, and educator training for effective implementation (see Sections 3.1–3.3; pp.2-5).

5. Discussions

A variety of perspectives were reflected in the lecturers' responses to the questions, which resulted in the findings shown above. The findings reveal that, despite the increasing adoption of digital technology in EGD instruction, the interactive and design-oriented uses of technology remain notably constrained. While the lecturers consistently recognise the value of digital tools for enhancing flexibility, resource sharing, student engagement, and assessment, most technology use is limited to content delivery and administrative functions such as distributing materials via Moodle or communicating through platforms like Microsoft Teams and WhatsApp (Turnbull et al., 2023; Sjöberg & Holmgren, 2021).

One primary reason for this limitation is infrastructural inadequacy: unreliable internet connectivity, insufficient access to devices, and a lack of advanced, discipline-specific software such as AutoCAD pose substantial barriers to the implementation of interactive, hands-on digital design activities (Maphalala & Adigun, 2021; Ramoroka, 2021; Sá & Serpa, 2020). These challenges are particularly acute in resource constrained contexts, where institutions struggle to

provide both the necessary hardware and network infrastructure to support robust technology integration.

Another critical factor is the lack of targeted professional development. Although the lecturers demonstrated competence with basic digital platforms, many expressed uncertainties and the lack of confidence in using technology for dynamic, design-oriented pedagogy (Abedi, 2024; Adarkwah, 2021; Sackstein et al., 2022). The study showed that while the lecturers utilised projectors, document cameras, and multimedia resources, they often lacked pedagogical training to maximise these technologies for interactive, student-centred learning especially in the practical components of EGD, where fostering spatial imagination is vital (see also Section 3.1).

The socioeconomic disparities further exacerbate these constraints. The students' limited access to digital devices, mobile data, and reliable internet outside of campus not only reduced opportunities for engagement with interactive technology but also discouraged the lecturers from adopting approaches that may not be accessible to all the learners (Mtshali, 2020; Sjöberg & Holmgren, 2021). Consequently, digital technology use remains largely superficial, with little progress toward deeper, collaborative, or design-based applications, as highlighted by Sharlovych et al. (2023).

To address these limitations, both literature and study findings converge on the need for systemic interventions: as they investment in technological infrastructure, equitable access to discipline-specific tools, and context-specific professional development for lecturers (Sackstein et al., 2022; Vaughan et al., 2023). Only by overcoming these persistent barriers can EGD instruction realise the full potential of digital technologies to support interactive, creative, and design-oriented learning, as envisioned in educational theory and best practice.

The study highlights that to effectively harness digital technologies in EGD, there must be a strong emphasis on targeted professional development for lecturers and substantial investment in technological infrastructure. Addressing ongoing challenges such as inadequate connectivity, limited device access, and insufficient software is essential for creating meaningful hands-on learning experiences. Additionally, promoting equity and access remains crucial, as socioeconomic disparities can hinder the students' ability to participate fully in digitally enhanced education. Initiatives such as providing affordable devices or campus-based digital resource hubs can help to bridge these gaps.

Furthermore, the findings underscore that successful technology integration requires more than just providing digital tools; as it calls for a fundamental shift toward interactive, design-oriented pedagogy supported by curriculum redesign and collaborative digital platforms. The implications extend to informing institutional policy, guiding resource allocation, and shaping sustainable approaches to digital transformation in technical education. Future research should explore effective professional development models, the impact of infrastructure improvements, and innovative uses of digital technology, with

longitudinal studies offering insights into long-term outcomes. Ultimately, realising the transformative potential of technology in EGD depends on addressing these interconnected factors systemically.

6. Conclusion and recommendations

The incorporation of digital technologies in EGD training creates both opportunities and challenges. While the lecturers apply a variety of digital platforms to improve student engagement, collaboration, and learning flexibility, their efforts are hampered by insufficient infrastructure, a lack of digital proficiency training, and limited access to critical software like AutoCAD. Moodle is an important tool for material delivery and student involvement, although interaction in practical activities is still a worry. To take advantage of the full benefits of digital technology in EGD learning and teaching, educational institutions must invest in technological infrastructure, provide concentrated professional development for lecturers, and ensure access to critical digital tools. Addressing these problems allows the lecturers to effectively employ digital resources to increase the students' conceptual understanding, spatial visualisation, and overall technical skills.

Considering the limitations of the study, the researchers also recommend conducting more extensive research on more South African universities. Future qualitative research could think about employing a larger and more diverse sample of academic staff from other departments, faculties, and institutions to increase the breadth and transferability of findings. Deliberate methods such as maximum variation sampling or multi-site case studies could be utilised to collect a wider range of experiences while maintaining qualitative depth. Additionally, combining interviews with other qualitative methods like focus groups, classroom observations, or document analysis could enhance data triangulation and provide a deeper understanding of the subject under study.

The findings of such an extensive investigation could guarantee that all EGD lecturers and students at South African HEIs have access to digital technologies for educational teaching and learning. Furthermore, multi-site studies that include the students' opinions on technology integration in EGD classroom practices could provide a wealth of information concerning technology integration. The conclusions drawn from the participants' assessments of the current level of digital technology integration into EGD teaching processes may then be extrapolated and used at other universities on a larger research scale.

Conflict of Interest

All the authors had no conflict of interest in this paper.

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Appendix 1: Interview schedule for EGD Lecturers

Introduction:
My name is Lwandile Mzomba, and I am a master's student at the Faculty of Educational Sciences at Walter Sisulu University. I am conducting a research study that seeks to explore and describe the integration of digital technology with the instructional process in engineering graphics and design at a university in South Africa. I appreciate you taking the time to participate in this interview, and please keep in mind that this is solely for academic purposes.

1. How do the lecturers integrate digital technologies into the instructional process used in EGD?
1.1. Can you describe how digital technologies are currently integrated into your instructional strategies in EGD?
1.2. What specific digital tools or software do you use to enhance teaching and learning in EGD? How do these tools contribute to the instructional process?
2. How is the EGD curriculum developed to incorporate digital technology?
2.1. How is the EGD curriculum structured to incorporate digital technology? Could you provide examples of how digital technology is integrated into different modules or units?
3. What effect does the integration of digital technology have on student commitment to engage and participate in EGD topics?
3.1. In your experience, what impact does the integration of digital technology have on student engagement and participation in EGD topics? Can you share any specific instances or observations?
3.2. How do you assess the effectiveness of digital technology integration in improving student learning outcomes and instructional process?
4. What technological infrastructure and support systems are in place to facilitate the effective integration of digital technology in EGD instructional process?
4.1. What challenges do you face in integrating digital technology into your EGD curriculum? How do you overcome these challenges?
4.2. What support or resources do you require to facilitate the effective integration of digital technology into teaching EGD? And why?