

Understanding technology integration in STEM classrooms: Examining the challenges and perceptions of engineering graphics and design teachers and learners

Boniswa Kubheka¹ 

Philani Brian Mlambo² 

^{1,2}Faculty of Arts and Design, School of Education, Durban University of Technology, South Africa.

¹Email: boniswa.k@icloud.com

²Email: PhilaniM7@dut.ac.za



( Corresponding Author)

Abstract

This qualitative study aimed to examine challenges faced by both Engineering Graphics and Design (EGD) teachers and learners in integrating technology into teaching and learning. Data were gathered through semi-structured interviews and an open-ended questionnaire administered to six teachers and twelve learners from four selected schools in the uThukela District of KwaZulu-Natal. Participants were purposively selected based on their experiences with EGD. The study was informed by the Technology Acceptance Model (TAM), with particular emphasis on perceived usefulness and perceived ease of use as key determinants of behavioural intention. Data were analysed using thematic analysis to capture and interpret the perspectives of both teachers and learners. The findings indicate that participants perceive technology as valuable in enhancing understanding, spatial reasoning, and learner engagement. However, several persistent challenges were identified, including inadequate infrastructure, insufficient training, limited resources, and inconsistent or absent internet connectivity. The study concludes that addressing infrastructural disparities and strengthening teacher competence through targeted training and improved resource allocation are critical for effective technology integration in EGD. It further recommends that the Department of Education invest more in infrastructure and resources, provide focused Information Communication Technology (ICT) training for teachers, and promote partnerships with industry to bridge existing gaps.

Keywords: Digital divide, Digital skills, Engineering graphics and design, Fourth industrial revolution, Technology acceptance model, Technology adoption.

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Contribution of this paper to the literature

This study contributes to the current trends research investigating the integration of technology into teaching and learning of EGD. As much as this is a current trend, this study adds a new dimension: Most studies in EGD investigate teachers; this study investigates both teachers and learners.

1. Introduction

Preparing learners for careers in technical and engineering fields, Engineering Graphics and Design (EGD) plays a vital role. It is an introductory subject that fosters the spatial thinking, problem-solving, and design abilities necessary for careers in manufacturing, civil engineering, architecture, and industrial design (Makgato & Khoza, 2016). EGD is acknowledged as a crucial subject in solving the national skills shortages and promoting economic growth in South Africa, where engineering and technical skills are in demand (Singh-Pillay & Sotsaka, 2022). It guarantees that learners are better equipped for post-secondary education, training in Further Education and Training (FET) colleges, and the workforce by giving them the tools to visualise, communicate, and create technical drawings (Makgato & Khoza, 2016).

In response to the increasing need for technical skills, EGD was formally incorporated into the Grades 10–12 curriculum through the Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2011) in 2002 to update, modernise, and standardise the curriculum as part of the Revised National Curriculum Statement (NCS) (Department of Basic Education, 2011). To prepare learners for employment in engineering, architecture, and allied professions, the Department of Education's main goal was to equip them with a solid understanding of technical drawing, design principles, and spatial visualisation (Makgato & Khoza, 2016). Practical assessment tasks (PATs) covering subjects including isometric drawing, sectional views, assembly drawing, and computer-aided design (CAD) are part of CAPS, which also describes the subject's content, assessment techniques, and career routes (Singh-Pillay, 2024). These teaching materials are core in improving learners' technical development and problem-solving skills.

To achieve high economic development, an industrialised society, and combat unemployment, according to the National Development Plan (NDP) 2030, the critical component is the creation of a competent and skilled labour force (National Planning Commission, 2011). The NDP 2030 has identified a severe shortage of skills among those who are practising engineering. Therefore, by offering learners the needed technical skills necessary for engineering, manufacturing, and construction industries, EGD meets the objective (Makgato & Khoza, 2016). Singh-Pillay (2024) asserted that implementing EGD in the NSC stage of education contributes to skills development and ensures that learners are, at an early age, ready to navigate higher education or careers in technical sectors.

Globally, programmes and initiatives like the United Nations Sustainable Development Goal 4 (SDG 4) place emphasis on promoting opportunities for lifelong learning for everyone, as well as inclusive and equitable quality education (United Nations, 2015). By giving learners the technical, analytical, and problem-solving skills needed in the engineering, manufacturing, and construction industries, EGD directly supports these objectives (Makgato & Khoza, 2016). In addition to addressing the country's skills shortage, South Africa is joining international efforts to prepare young people for technical careers by implementing EGD in the senior phase of education. EGD in schools serves as the foundation for FET colleges.

TVET colleges provide specialised programmes that include the National Certificate Vocational (NCV) and National Diploma courses in engineering fields, which incorporate EGD modules. Learners who take these subjects prepare for employment as technicians, draughtspersons, and artisans in the mechanical, electrical, and civil engineering sectors by gaining practical skills in drafting, CAD, and technical communication (Ngcobo, 2025; University of Pretoria, 2024). The starting of EGD subjects in the senior phase, that is, from Grade 10 to 12, is a fundamental strategy that not only aligns with the national development goals but also supports a smooth shift of skills from the senior phase to higher education and then the labour market (Singh-Pillay, 2024).

In many South African schools, the teaching and learning of EGD is negatively impacted despite its importance to the economy and labour market. One critical problem that severely hinders the quality of teaching and learning in EGD is the scarcity of essential material, including AutoCAD software, 3-Dimensional models, and drawing tools. Mlambo (2024) notes that the importance of EGD is to teach learners drawing techniques and technical skills so that they may interpret and produce drawings within complex subjects like assembly or isometric drawing.

While the resources are essential for enhancing teaching and learning, parallel to that is the challenge of teachers' readiness. Despite policy support by NDP 2030 and national development goals, many teachers face significant multi-layered obstacles in using ICT (Blose, 2023). The key challenges for teachers include unreliable electricity and internet access, limited training and technical skills, even though regulations support integration (Blose, 2023; Mlambo, Maeko, & Khoza, 2023). Therefore, the perceived usefulness and ease of use of technical tools are negatively impacted, further ensuring skills shortage and poor performance (Singh-Pillay, 2024).

The lack of adequate training and resources has resulted in multifaceted obstacles in the teaching and learning of EGD. Several studies and diagnostic tests have found that poor performance is a result of the quality of teaching and learners' insufficient understanding of the material discussed in class (Mlambo, 2024; Zwane, Simelane-Mnisi, & Skosana, 2021). An intervention necessary to mitigate this challenge ought to ensure that necessary resources for EGD are provided and teacher development is ensured so that the national development goals and NDP 2030 are observed (Naidoo & Singh-Pillay, 2020). Furthermore, this is critical in ensuring that scarce skills like EGD or Science, Technology, Engineering, and Mathematics (STEM) fields are enrolled in (Naidoo & Singh-Pillay, 2020).

1.1. Research Problem

Despite EGD being one of the scarce fields but critical to ensuring economic growth, Mlambo (2024) and Zwane et al. (2021) maintain that several schools in KwaZulu-Natal are still confronted with several obstacles in their aim to deliver EGD education effectively, regardless of its significance in the labour market. Mlambo (2024) asserts that for EGD to be effectively delivered, there is a need for classrooms to have access to needed and necessary teaching resources, which include AutoCAD software, 3-dimensional models, drawing tools, and instructional DVDs.

Additionally, Zwane et al. (2021) confirm that the necessary teaching resources enable learners to develop spatial vision and technical drawing skills, making it easier to understand complex subjects such as isometric and assembly drawings. However, most teachers maintain that such teaching tools are either absent or that they lack the skills or training to use them, which affects the performance and understanding of most learners (Mlambo et al., 2023).

The national diagnostic tests have revealed that both a lack of access to needed resources for EGD classrooms and limited training and technical skills by teachers have been the reasons for continuous poor performance in EGD teaching and learning (Mlambo, 2024). Although several national and global policies have been advocating the incorporation of ICT into classrooms, on-the-ground pedagogical and resource issues have ensured a stressful and ineffective adoption (Blose, 2023). Moreover, the issue of teachers' development and lack of teaching resources is a topic that is overlooked, which puts at a disadvantage the critical objective of the EGD curriculum (Mlambo, 2024).

1.2. Research Aim and Research Questions

The primary goal of the study was to explore the challenges faced by engineering graphics and design (EGD) teachers and learners in adopting technology in their teaching and learning. The main goal of the study was guided by the following research question: What challenges do EGD teachers and learners face in adopting technology during teaching and learning?

2. Theoretical Framework

2.1. Technology Acceptance Model

The Technology Acceptance Model (TAM) by Davis (1989) is the theoretical framework used to support the study. The TAM is a model used in research related to the use of technology in education, following concerns of resistance or underperformance in newly introduced technology (Venkatesh & Davis, 2000). TAM is a critical tool for predicting the level of use and acceptance of any ICT tool by an individual or organisation (Davis, 1989). It is an effective model based on Ajzen and Fishbein (1980) Theory of Reasoned Action (TRA). The TAM, in Venkatesh and Davis (2000) view, addresses the attitude of an individual, how they use technological tools, accept and adopt them. According to the model, the individual's attitude has two determinants, which are perceived usefulness (PU) and perceived ease of use (PEOU). Davis (1989) and Venkatesh and Bala (2008) assert that the two determinants are the critical elements in the model that influence the actual use, acceptance, and adoption of technical tools.

TAM is a frequently used model in research on technology in education, making it a perfect fit to view the attitudes of teachers and learners in using, accepting, and adopting technical tools. By viewing their attitudes, what motivates them, and their perspectives, the study did not merely respond to why teachers decide to use and accept technology but addressed why they decide to do so (Scherer, Siddiq, & Tondeur, 2019). According to Schwab (2016) and UNESCO (2019), there has been a pressing national and global motivation to integrate ICT into the classroom, in line with the Fourth Industrial Revolution (4IR) objective. TAM is a fit for the study, as it argues that successful use, acceptance, and adoption lie with the end user's attitude. In this case, teachers' and learners' attitudes and perceptions will be a focal point (Ertmer & Ottenbreit-Leftwich, 2010).

Hennessy, Ruthven, and Brindley (2005) assert that the necessary ICT infrastructure is important for effective education; however, parallel to this is the pedagogical competence and teachers' use and acceptance of such infrastructure. Ertmer and Ottenbreit-Leftwich (2010) maintain that pedagogical and digital competence do not ensure that well-equipped schools will take advantage of the available technical tools. However, teachers are more motivated to use, accept, and adopt technical tools when they are seen as helpful and easy to use (Teo, 2011). In addressing challenges in EGD, TAM helps understand teachers' attitude, motivation, and cognitive variables towards technology integration (Chigona & Chigona, 2010). To address challenges in the adoption of technology in education, TAM is a crucial framework for providing attitudes and behavioural intention of individuals (Venkatesh & Bala, 2008).

3. Research Methodology

3.1. Research Paradigm

The study is based on the interpretivism paradigm. Interpretivism in qualitative study is a research paradigm that aims to understand intricate behaviour in human, social context, and subject meaning surrounding experiences and attitudes (Slevitch, 2011). Cohen, Manion, and Morrison (2018) argue that in the interpretivist paradigm, information and knowledge are collected through participants' perceptions and understanding of their socially constructed reality. This paradigm is suitable for the study's objectives, which aimed to explore the challenges faced by engineering graphics and design (EGD) teachers and learners in the adoption of technology in teaching and learning.

Nieuwenhuis (2016) maintains that interpretivism can ensure that factors that contribute to participants' attitudes and behaviour are better understood under the paradigm. The paradigm encourages a qualitative inquiry to understand various complex perceptions of individual teachers in KwaZulu-Natal's uThukela District. The interpretivist paradigm, through the use of semi-structured interviews and open-ended questionnaires, can address challenges in the adoption of EGD subjects.

3.2. Research Approach

This study embraced the qualitative method to better understand teachers' and learners' perceptions and experiences of the adoption of technology in the EGD classroom. Qualitative data, unlike quantitative data, can be critical in providing an informed and rich understanding of knowledge (Flick, 2014). Additionally, Strauss and Corbin (1990) emphasise that qualitative research is the right methodology for research that seeks to obtain a detailed description of lived experiences, participants' feelings, and emotions about an event in their social setting. Furthermore, qualitative research helps comprehend people's feelings and perspectives, as well as investigate complex social realities. It enables the researcher to get detailed, descriptive data that illustrates how participants interpret their learning settings and the elements influencing their capacity for successful technology integration. In

contrast, the depth of the research makes the sample a bit smaller, and the researcher is not able to generalise to the whole population (Rahman, 2017).

3.3. Sample / Participants / Group

To specifically select participants with experience related to EGD, purposive sampling was employed. Therefore, to select people who can offer rich, in-depth knowledge of the research topic, the researcher uses their judgment to select the sample. Purposive sampling was suitable because only participants who are actively involved in teaching or learning EGD were included, which was reasonable given the small number of schools that provide EGD. This method improved the quality and applicability of the data gathered by enabling the researcher to concentrate on a more intimately understood, smaller sample of participants (Creswell & Creswell, 2018). Purposive sampling is useful in qualitative research when the goal is to obtain profound insights rather than statistical representation, even though it does not permit generalisation to a larger population (Etikan, Musa, & Alkassim, 2016). Hence, the main goal was to select informed participants to gain more insight into the challenges and factors hindering the effective delivery of EGD.

The study population comprised EGD teachers and Grade 12 EGD learners from four selected schools in KwaZulu-Natal’s uThukela District. The study participants were divided into two groups: six teachers and 12 learners. Both groups were important in offering a variety of viewpoints about the challenges and factors hindering the effective delivery of EGD. Additionally, the diverse population with different backgrounds contributes not only to providing rich, informed knowledge but also to a thorough understanding of the challenges in EGD. Table 1 shows the biographical information of the participants who were sampled in this study.

Table 1. Participants' biographical information.

Schools	Name of Teacher	Gender	Majors	Teaching Experience
School A	Teacher 1	Female	EGD and Mechanical Technology	7 years
	Teacher 2	Male	EGD and Civil Technology	4 years
School B	Teacher 3	Female	EGD and Civil Technology	5 years
	Teacher 4	Male	EGD and Electrical Technology	2 years
School C	Teacher 5	Male	EGD and Electrical Technology	13 years
School D	Teacher 6	Female	EGD and Civil Technology	2 years

The table above shows the teachers who were sampled in this study from 4 schools in the uThukela District. These teachers were purposely sampled because of their experience with EGD. As mentioned above, this study collected data from EGD teachers and learners; as a result, only 3 Grade 12 learners were sampled from each school to participate in this study.

3.4. Instrument and Procedures

The study collected qualitative data through semi-structured interviews and an open-ended questionnaire. The instruments were used to ensure that descriptive information gave out data that showed perception, attitudes, and opinions on the adoption of technology in the EGD classroom. Semi-structured interviews were conducted with teachers in the EGD classrooms; each interview lasted about an hour to one and a half hours, depending on the participant's depth. Ritchie and Lewis (2003) define semi-structured interviews as a qualitative data collection method that looks like a flexible interaction, guided by set open-ended questions. The method of data collection allows participants to open up and for the researcher to ask follow-up questions.

Semi-structured interviews allow researchers to collect reliable data from key informants with first-hand experience, information, and perception relating to the topic (DeJonckheere & Vaughn, 2019). As a result, they will give the research in-depth, informed data. Open-ended questionnaires were administered to learners in the EGD classroom and required approximately 30 to 45 minutes to complete. Open-ended questions are useful in qualitative research because they enable participants to answer in their own terms, yielding rich and detailed data (Creswell & Creswell, 2018).

3.5. Data Analysis

The data was analysed using the thematic analysis methodology, which is a methodical process of finding, classifying, and interpreting patterns or themes in data (Braun & Clarke, 2006). Initial codes were generated when the procedure started with familiarisation through repeated readings of the transcripts and responses. The codes are grouped into themes that single out recurring trends related to the adoption of technology.

4. Research Rigour

4.1. Credibility and Validity

Member checking, as a technique that builds credibility, was used by returning data interpretation to participants, giving them a chance to verify the accuracy of their responses. Credibility is a qualitative research technique that relates to the trustworthiness, accuracy, and reliability of the interpretation of data (Creswell & Creswell, 2018). By facilitating cross-verification of data, the use of both teachers and learners as data sources improved the findings’ internal validity.

4.2. Dependability and Reliability

Using a uniform data-gathering process for all participants, reliability was guaranteed. Transcripts and audio recordings were meticulously recorded and safely preserved. Noble and Smith (2015) suggest that documenting and sharing the research process ensures the reliability of data and makes the qualitative interpretation transparent and replicable for other researchers.

4.3. Triangulation

The use of open-ended questionnaires and semi-structured interviews was important to ensure triangulation. According to Denzin (2012), triangulation enhances the validity of qualitative research by validating data from several sources and viewpoints. The results were solid and represented a range of perspectives, using a multi-method approach and a range of sources of information.

4.4. Ethical Consideration

Before the study began, the researchers received ethical approval from the Durban University of Technology Ethics Committee. The importance of ethical considerations lies in their function as social norms that guide acceptable and unacceptable behaviour (Shah, 2011). Research ethics were strictly observed to ensure participant privacy and a smooth data collection process. Permission to conduct the study was obtained from the four principals of EGD-offering schools in the uThukela District, KwaZulu-Natal. Teachers were interviewed during their free periods in EGD class to avoid disrupting teaching and learning.

Data were collected through semi-structured interviews and open-ended questionnaires, with no interference in classroom activities. All learners involved were over 18, so consent was sought directly from them rather than from their parents. Consent forms were provided to all participants, assuring them that participation was voluntary and that they could withdraw at any time without consequences.

5. Results

As mentioned above, data were collected from teachers and learners to understand the challenges and perceptions in the adoption of technology in teaching and learning of EGD. The participants were sampled from their secondary schools in uThukela District, as can be seen in biographical table 1 above. The participants comprised six EGD teachers and 12 learners.

5.1. Presentation and Discussion of Findings from EGD Teachers

Semi-structured interviews and open-ended questionnaires were analysed following a thematic analysis by Braun and Clarke (2006). Below is the analysis of the data from the semi-structured interviews, discussed under three main themes: (Resources and infrastructure, Digital skills and readiness, and Perceptions and adoption).

Theme 1: Resources and infrastructure

When asked about the availability of resources and infrastructure, the majority of the interviewed teachers emphasised a lack of digital resources for teaching EGD. This lack was observed in schools with a predominantly African student body. Teachers 1 and 2 from different schools with an African student body emphasised that important CAD software, projectors, and well-equipped computer labs were not available at their schools.

Teacher 1 noted: “Our school has very limited and no digital resources for EGD. We do not have access to CAD software or digital drawing programmes, and the computer facilities are not equipped for technical drawing work. Teaching is mostly manual, using drawing boards, instruments, and printed diagrams. Even basic materials such as A3 paper are sometimes difficult to procure due to budget constraints.”

Teacher 2 confirmed: “I am teaching grade 11 and grade 12; I have been teaching EGD since 2023. I didn’t teach in 2024. My teaching experience has been very difficult because there is no digital technology at my school. I use drawing instruments, and I draw on the board.”

These circumstances reflect a global pattern in which EGD, a subject that requires a high level of technical proficiency, is underfunded, particularly in township and rural schools. In line with the finding above (Makgato & Khoza, 2016), it was discovered that EGD classrooms without access to digital tools fall short of modern industrial and design standards. Mlitwa and Nonyane (2008) also point out that the lack of ICT infrastructure in many South African schools restricts teachers’ ability to adopt technology effectively.

While the Department of Basic Education (2011) maintains that inequitable resource distribution continues to disadvantage historically Black schools, hence sustaining the racial and digital divide in education. Venkatesh and Davis (2000) further confirm that teachers’ perceptions of the usefulness and ease of use of digital technologies are adversely affected by a lack of infrastructure. Teachers are less likely to recognise the usefulness of EGD training or feel comfortable using it when they lack access to the technology needed for it (Teo, 2011). As a result, teachers who lack resources are less likely to embrace technology because they believe it is unfeasible and outside of their control (Gumbo, 2018).

On the other hand, Teacher 4 from an urban, historically white school portrayed an EGD classroom that is fully integrated with digital technology and has ample resources.

Teacher 4 noted: “I use a projector and a tool that allows me to draw at my desk, and it projects behind what I am drawing so the students can follow along, and then I have a computer with TurboCAD and AutoCAD and various programmes and access to the internet, including YouTube and so forth.”

This experience demonstrates how adequate infrastructure improves learner involvement and teaching effectiveness (Mlambo et al., 2023). Perceived usefulness and perceived ease of use promote favourable attitudes toward technology integration, as demonstrated by the teacher’s proficiency with those digital tools. Digital technology has transformed technical and engineering education by ensuring a learning experience that aligns with modern and industry standards like 4IR (Maisiri, Darwish, & van Dyk, 2019). Additionally, sufficient access to digital technology, training, and professional development enhances teachers’ perception and attitude toward the adoption of technology, therefore increasing readiness for use in teaching. Ngcobo (2025) has observed that schools with access to needed technical resources have teachers who are competent in technology use and produce learners who outperform in EGD subjects.

Teachers 1, 2, and 4 have highlighted different experiences in the South African education system, which also highlight the dual reality experienced by many disadvantaged groups in the country. Teachers in resource-poor schools frequently lack digital skills and training to use technology, due to challenges that result in low levels of ease of use and perceived usefulness (Hart & Laher, 2015). Additionally, moving beyond willingness and availability of resources, findings have suggested that structural and historical inequalities significantly affect EGD teachers’ use

of technology (Department of Basic Education, 2011). In South Africa, the digital divide by race, gender, and location goes beyond just the need for teacher training (Singh-Pillay, 2024). These measures include systemic infrastructure investment, equal funding, and policy enforcement. Therefore, closing these infrastructure gaps and developing supportive learning environments in all schools are essential to raising EGD teachers' perceptions of the usefulness and ease of use of technology.

Theme 2: Digital skills and readiness

When teachers were asked about their digital skills and ability to engage with digital technology, several teachers who were interviewed showed a lack of digital abilities and readiness. Of the 5 participants, 4 reported never having had any professional training or development in digital tools like AutoCAD or TurboCAD. Even the one who had training, it was during their university years.

Teacher 5 noted: "We are never developed or get any training; we have to find our own ways of teaching," while another teacher, Teacher 2, explained, "Not yet; I have never received any training before."

Even Teacher 4, who had access to sufficient digital resources, reported not receiving any formal training during their teaching experience, but expressed a willingness to learn, stating, "I could do training for AutoCAD and TurboCAD; the problem is the children are not tested on them... If they make an option for children to do the entire pattern on AutoCAD and TurboCAD, it will help them in the future."

This demonstrates the discrepancy between the actual implementation in EGD classes and the policy's goals for technological adoption in schools. These results are consistent with the view that low adoption rates result from teachers who lack confidence and training, viewing digital tools as challenging to use (Venkatesh & Davis, 2000). Albirini (2006) discovered that teachers' attitudes towards technology are influenced by their experience, competence, and institutional support. Based on the search findings, 4 teachers expressed unease and a lack of readiness to implement digital technology in classrooms. According to the study, teacher readiness and adoption of digital tools are mainly motivated by appropriate training and infrastructure rather than a dislike of change.

Singh-Pillay (2024) argues that due to a lack of digital skills and professional development, many teachers in South Africa express frustration when integrating ICT into EGD classrooms. Another common challenge in the adoption of digital tools includes: a mismatch between educational policies and curriculum, a lack of departmental support, and the digital divide in the educational system. Additionally, Blose (2023) asserts that the digital divide is further maintained by a lack of ICT-targeted professional training for teachers teaching in underfunded schools. South Africa's educational system still exhibits wider racial and socioeconomic disparities, which are reflected in this digital gap (Naidoo & Singh-Pillay, 2020). However, the experience of Teacher 4 illustrates the transformative power of sufficient digital resources and a nurturing environment, as argued by TAM.

Theme 3: Perceptions and adoption

In response to the participants' views on the adoption of technology in the EGD classroom, all participants generally expressed strong support for its adoption. Therefore, acknowledging its potential for ensuring an improved learning environment and effective engagement by all parties. Based on the study findings, all teachers acknowledged that digital technologies are critical in EGD classrooms to enhance learning in subjects like architecture and engineering. In addition, the participants emphasised that digital technology in the EGD classroom makes lessons more interesting while still meeting the demands of the 4IR objective. The view that digital technology can enhance positive learning is consistent with the TAM model. TAM maintains that teachers' attitude towards the adoption of technology can be positive when they believe it to be helpful and practical (Venkatesh & Davis, 2000).

Teacher 6 asserts: "I think it would be easy because the amount of time you spend on the board compared to when you are using other instruments, I think it would make it easy for me if I were provided with those tools."

The response by Teacher 6 confirms that teachers are aware that digital technology can be useful for the effectiveness of the EGD classroom, indicating a shift in mindset, which mirrors the aim of TAM: perceived usefulness and ease of use.

Teacher 4 from school with resource maintained: "Visually, it helps a lot to show the students video objects... I can record videos and send them so they can replay them at home, and that helps a lot."

Two parallel aspects of digital education are having access to digital technology to allow varied teaching, where teachers can make lessons to meet learners' needs, while also improving visual learning (Ertmer & Ottenbreit-Leftwich, 2010). Based on the research results, there was a positive review of digital technology's potential to improve teaching and learning; however, most teachers noted significant barriers to classroom adoption. The findings are consistent with Singh-Pillay (2024) and Blose (2023), who claim that teachers in EGD classrooms face significant ICT integration challenges determined by a lack of infrastructure, inadequate resources, and a lack of digital expertise.

Ertmer and Ottenbreit-Leftwich (2010) contend that second-order challenges to technology adoption are those basic interpersonal difficulties relating to attitude, confidence, and pedagogical understanding, when physical resources are insufficient. The implementation gap between the teachers' willingness to use technology is silenced by limitations and contextual constraints. Mlambo et al. (2023) assert that most teachers have come to recognise the potential benefits of using technology in the classroom, but sustainable adoption in classrooms is hindered by professional development. In support of those findings, Gumbo (2018) notes that positive perception alone is insufficient for effective adoption of digital technology, making professional development and institutional support essential for a positive attitude. The findings of this study suggest that teachers are positive about the potential benefits of digital technology; however, their acceptance is hampered by the digital divide and institutional injustices.

Having presented and discussed the findings from EGD teachers, the study now shifts its focus to learners' perspectives. This section highlights learners' experiences, challenges, and perceptions of technology use in EGD classrooms.

5.2. Presentation and Discussion of Results from Learners

Following teachers' semi-structured interviews, learners were administered open-ended questionnaires to understand their challenges and perceptions regarding the adoption of technology in the teaching and learning of EGD. Below are the presentation and discussion of findings from EGD learners.

Theme 1: Learning Experience

When the learners were asked about their technology and learning experience, the interview findings further revealed clear inequalities in learners' learning experiences, which are influenced by access to technological resources and infrastructure.

Learner 1 stated,

"The teacher once used a video, and it made the teaching and learning clearer, but from then on, the infrastructure of the facility was broken."

Similarly, Learner 9 expressed,

"I have to use the nearest library, if possible, or my own internet if I have to learn the application side of my study from YouTube for clarity."

These experiences demonstrate how active learning and understanding of concepts are hindered by a lack of technology exposure in EGD classrooms. The findings are consistent with those of Mlambo et al. (2023), who discovered that learners in South African schools with limited resources frequently use self-directed online learning to make up for educational gaps. The learner usage of YouTube and other online learning tools for EGD lends credence to Mteleli, Mtshali, and Skosana (2026), who argue that digital learning improves problem-solving and visualization, two critical abilities in technical subjects. However, restricted access to technology leads to disconnected educational experiences, which exacerbates inequalities among schools (Mlambo et al., 2023).

Theme 2: Learning Environment and Resources

When students were asked about CAD software and other technological tools used in EGD, the researcher identified a clear digital divide in the study between learners from the African and white schools.

Learner 2 said,

"My school does not have a simple A2 or A1 paper; they don't have complex stuff or technology like those you just asked me about, CAD. What is that?"

Whereas Learner 5 added,

"My school does not have any technological resources; we do not even have computers." In contrast to the two learners above."

Learner 10 from a well-resourced, predominantly white school reported.

"Every day, because most of the things we do, Sir shows us using a projector."

The contrast draws attention to the ongoing racial, resource, and infrastructure inequalities in South African education, which are the results of the unfair resource distribution that occurred during apartheid (Blose, 2023). The results support the claims made by Singh-Pillay (2024) that the quality of teaching and learning in EGD is directly impacted by resource inequalities. The results support the body of research showing that one of the biggest problems facing South Africa's educational system is still ensuring that all students have fair access to instructional technology.

Theme 3: Perception of Technology in Learning

Despite the learner's limited exposure, every student had a positive perception of technology and said they would embrace it if it were made available.

Learner 8 noted,

"To support my learning, I normally outsource if our school has proper technology that will help learning and understanding."

Learner 9 further stated,

"It just makes learning interesting because some learners are visual learners, using technology makes it easier and more interesting to watch Sir do it."

The findings on perception of learners align with TAM, which argues that learners' willingness to embrace technology is influenced by perceived usefulness and ease of use (Venkatesh & Davis, 2000). The learners understand how technology may improve their learning clarity, engagement, and interactivity even in the absence of direct access. This backs up the claims made by that, given sufficient resources and assistance, a positive perception held by both teachers and learners can encourage the adoption of digital technology. With the same view, (Masingi & Khoza, 2024) noted that, given the right support, resources, and infrastructure, learners in schools with no to little resources frequently exhibit curiosity and passion for digital learning. While the study participants show that they are ready and willing to try digital learning, structural injustices and lack of institutional support still prevent them from taking full advantage of technology-enhanced EGD teaching.

6. Conclusions and Implications

In conclusion, there is a lot of promise for transforming teaching and learning through the use of digital technology in EGD education; systemic issues continue to be a significant obstacle. Fair access to high-quality EGD education is still being hindered by the ongoing digital divide between well-resourced and under-resourced schools, which frequently follows racial and geographic boundaries (Zwane et al., 2021). Teachers' capacity to successfully adopt new technologies is further restricted by their lack of ongoing professional development and low level of digital literacy (Mlambo et al., 2023). TAM maintains that without institutional backing and supporting infrastructure, positive views of technology's use do not always convert into adoption (Venkatesh & Bala, 2008). Thus, a conscious commitment to training, financing, and policy alignment with the National Planning Commission (2011), which advocates for the development of 4IR skills, is necessary to close the gap between perception and practice. In order to support the larger objectives of South Africa's educational transformation, improving digital readiness in EGD classrooms can improve learner performance, industrial relevance, and spatial thinking.

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