

Teachers' perspectives on infusing ICT in Engineering Graphics and Design pedagogies using the TPACK Framework

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ABSTRACT

The 21st century and the 4th Industrial Revolution have necessitated a shift in pedagogies, highlighting the importance of integrating Information and Communication Technology (ICT) into education. This study explored Engineering Graphics and Design (EGD) teachers' perspectives on the use of ICT in EGD classrooms, aiming to recommend strategies for effective integration using the Technological Pedagogical and Content Knowledge (TPACK) framework. Using a qualitative approach, data were collected from nine EGD teachers across secondary schools in the uMgungundlovu district of KwaZulu-Natal, South Africa, through semi-structured interviews and classroom observations. Thematic and descriptive analyses revealed that ICT plays a vital role in enhancing EGD instruction. Teachers demonstrated strong Technological Knowledge (TK) and effectively used tools such as AutoCAD and simulations to facilitate learners' understanding of complex concepts. They also showed competence in aligning technology with pedagogy (TPK) and content (TCK). However, their efforts were often constrained by limited infrastructure and outdated resources. These systemic challenges hinder the full realisation of ICT's potential in classrooms. The study recommends that the Department of Basic Education prioritize investment in ICT infrastructure and ensure equitable resource distribution. It also underscores the need for continuous professional development rooted in the TPACK framework and the creation of digital teaching resources. Furthermore, establishing professional learning communities is essential to foster collaboration and improve the integration of ICT in teaching practices. These measures are

crucial for empowering teachers and preparing learners for the demands of a technologically driven world.

Keywords: Engineering Graphics and Design, Teaching Pedagogies, Information and Communication Technology, Teachers

INTRODUCTION

In the 21st century, the advancement of Information and Communications Technology (ICT) has brought about changes in teaching and learning pedagogies (Fleur & Dlamini, 2022). Over the past two decades, ICT has been the most important tool for all parts of our lives. It appears that many factors have contributed to this rapid change in the advancement of ICT. Indeed, the use of ICTs in teaching and learning has significantly improved to enhance educational practices and student learning (Boateng et al., 2025). But the COVID-19 outbreak and the migration of the world to digital learning remain key drivers as the world is embracing the Fourth Industrial Revolution (4IR). As attested by Wyk et al. (2020), COVID-19 has compelled educational institutions to come up with alternative ways to supplement the traditional teaching approach. Undeniably, according to literature, this sudden transition has undoubtedly caused an incredible amount of damage and disruption to the traditional teaching approaches (Mafenya, 2022). As attested by Abraham and Otuaga (2017), pencil on paper final work for drawings (building plan, mechanical drawing etc.) are no longer recognized in the society because we are in the era of ICT. Integrating ICT into EGD instruction is one way to supplement the traditional teaching approach.

According to the Curriculum and Assessment Policy Statement (CAPS) document, Engineering Graphics and Design (EGD) is a subject offered in the Further Education and Training (FET) phase, which is Grades 10–12 in secondary schools (DBE, 2011). EGD is one of the technical-practical subjects that mainly focusses on linework, accuracy, and neatness. Understanding the different types of lines used in EGD is crucial to understanding line work. This notion is echoed by Khoza (2018), that there are 10 different lines that are used in EGD, and all these 10 different lines have different meanings altogether. Therefore, it is imperative for learners who are doing EGD to understand all these 10 different lines and the impact that they can have on drawings. For instance, a dotted line may appear insignificant to someone unfamiliar with EGD, but in EGD, it signifies a hidden element. That is because EGD mainly focuses on teaching principles that have both academic and technical applications (DBE, 2011). Within that context,

EGD's main emphasis is on basic knowledge and various drawing skills, which might prove to be very difficult to teach virtually. Unlike other academic subjects, EGD is practical by nature, requiring the ability to visualise graphics. In that context, teaching the subject online may indeed be difficult. Mlambo (2023) claims that unlike other academic subjects, those requiring practical hands-on learning like EGD appear to have several obstacles to overcome in virtual settings.

LITERATURE REVIEW

Virtual learning as a tool for infusing ICTs

Virtual learning (VL) refers to instruction delivered in environments where teachers and learners are separated by time or space, using tools such as IT applications, multimedia, and videoconferencing (Hue Dung, 2020). However, this might present multiple challenges to teachers, particularly those with little or no experience with the pedagogy known as “emergency remote modes” of teaching and learning (Rapanta et al., 2020). Platforms like WhatsApp, Zoom, and Microsoft Teams have diversified the modes of e-learning. According to Li and Lalani (2020), e-learning has improved learner retention, though Aslan (2022) notes that many teachers still prefer traditional teaching methods. In contrast, Oliveira and Bernardes (2021) argue that even technical subjects like Engineering Graphics and Design (EGD) can be effectively taught online, challenging long-held assumptions. Nonetheless, resistance among EGD teachers persists, largely due to limited ICT training and support (Mlambo et al., 2023). Li and Lalani (2020) also point out that technical challenges, such as unreliable internet and electricity, hinder the success of VL. In emergencies, VL can be a viable alternative to traditional instruction (Bloom, Reid & Cassady, 2020), but effective use demands strong ICT skills. Unfortunately, many teachers still struggle with digital demands (Mashile, 2017). While ICT has become a pillar of modern education (Moses and Paul, 2023), its integration into EGD remains unclear due to the subject’s complexity.

ICT enables a rethinking of EGD pedagogy by enhancing abstract concepts through digital manipulation (Torre et al., 2016; Khoza, 2021). However, barriers such as lack of confidence, competence, and resources persist (Kiwonde, 2020; Mlambo et al., 2023; Alharbi, 2021). Still, ICT offers curricular support, especially in abstract subjects like EGD, where spatial visualisation skills are crucial (Tiwari & Bhagat, 2024; Rodriguez & Rodriguez-Velazquez, 2017). Tools like AutoCAD have been shown to improve conceptual understanding (DBE, 2011; Sotsaka, 2019), and teachers used platforms like WhatsApp effectively during the COVID-19 lockdown (Mlambo,

2023). Despite increased availability of ICT in some schools, actual integration remains limited. Understanding teachers' perspectives is essential for bridging traditional methods with modern expectations, thereby enhancing learner engagement, comprehension, and preparation for digitally driven careers.

Importance of ICT training for teachers

The integration of Information and Communication Technology (ICT) into teaching and learning has gained increasing prominence, particularly as the world advances into the Fourth Industrial Revolution (4IR). More recently, the need to integrate ICT into education, especially within Engineering Graphics and Design (EGD) has gained renewed urgency following the COVID-19 pandemic. The global crisis forced educational institutions to rapidly shift to virtual learning platforms. While this transition was necessary to meet the evolving demands of education, many teachers were unprepared to deliver lessons virtually due to a lack of training. Onasanya et al. (2022) affirm that although the use of ICT in classrooms is not new and continues to grow in popularity, many teachers still lack the required training to implement it effectively. This was evident during the COVID-19 lockdown, when teachers in the uMgungundlovu district were reportedly unable to teach remotely due to insufficient ICT skills. Nyakito et al. (2021) attribute this to limited exposure to digital tools during pre-service training, which contributes to teachers' lack of confidence. Similarly, Adams (2020) warns that without adequate ICT training, teachers are at a disadvantage. Prakash (2022) also highlights the lack of digital competence as a major barrier, noting that insufficient training often leads to resistance in adopting new teaching methods.

Despite these challenges, some educators, as noted by Tusiime et al. (2020), still encourage learners to engage with digital technologies. Moreover, Sithole and Hahlani (2022) emphasize that while having computers in schools is important, teacher attitudes toward ICT play a crucial role in whether these tools are effectively used. Therefore, this study aims to explore EGD teachers' perceptions of ICT integration in their pedagogical practices, with the goal of informing strategies that enhance educational outcomes, foster creativity, and prepare learners for the demands of a technology-driven world.

TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE FRAMEWORK

This study focuses on the adoption and use of Information and Communication Technologies (ICT) in the teaching and learning of Engineering Graphics and Design (EGD). Its primary objective is to explore teachers' perspectives on ICT integration in EGD classrooms. To support this aim, the Technological Pedagogical and Content Knowledge (TPACK) framework, developed by Koehler and Mishra (2009), was adopted as the theoretical foundation. TPACK is particularly well-suited to this study because it provides a holistic lens for examining how technology intersects with pedagogical strategies and content knowledge in a subject-specific context. The TPACK framework comprises three core domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), which intersect to form an integrated understanding essential for effective technology integration in teaching. Technological Knowledge (TK) refers to teachers' abilities to use a range of digital tools and platforms to enhance instructional practices. Koehler et al. (2013) describe TK as "fluency of information technology," highlighting the importance of deep and practical knowledge of digital tools. In the EGD context, this includes tools such as AutoCAD, projectors, and whiteboards, which the Department of Basic Education (DBE, 2011) considers essential classroom resources. This component was investigated through interviews and classroom observations to understand how teachers practically apply technology in their lessons.

Technological Content Knowledge (TCK) explores the relationship between technology and subject matter, examining how digital tools can represent and transform content effectively. In EGD, where spatial and abstract reasoning is critical, selecting the right technologies is vital. Mtshali (2021) reports that many EGD teachers struggle with resource limitations, underscoring the importance of TCK in enhancing content delivery through appropriate technological means. On the other hand, Technological Pedagogical Knowledge (TPK) focuses on how technology influences instructional methods and strategies. It recognizes that digital tools can reshape how teachers teach and how students learn. Researchers such as Mlambo (2023) and Makgato (2016) emphasize the potential of digital technologies to improve learners' spatial visualisation skills, a key requirement in mastering EGD concepts. These three TPACK components directly informed the study's research questions and objectives, ensuring a comprehensive exploration of ICT integration from multiple pedagogical angles.

Although several other theoretical models were considered, TPACK was ultimately preferred for its comprehensive scope. The SAMR model (Substitution, Augmentation, Modification, Redefinition), developed by Puentedura, provides a useful lens for evaluating levels of technology use but lacks explicit attention to pedagogy and content, making it less suitable for subject-specific analysis like EGD. The Technological Acceptance Model (TAM) offers insights into users' attitudes toward technology based on perceived usefulness and ease of use but does not account for instructional or content-related considerations. Similarly, Rogers' (2003) Diffusion of Innovations Theory explains how technologies spread within communities but is less applicable to examining individual teachers' integration practices in the classroom. Compared to these models, TPACK offers a more nuanced and structured approach that captures the complex interplay between technology, teaching methods, and subject matter, particularly important for a visually demanding and technically complex subject like EGD.

Therefore, the TPACK framework is especially relevant to this study because it aligns closely with the practical demands of teaching EGD and the rapid evolution of educational technologies. It enables a structured analysis of whether teachers possess the necessary technological skills, how they align these skills with the subject content, and how effectively they adapt their pedagogical approaches. By adopting TPACK, this study aims to gain deeper insights into the enabling factors and barriers that influence ICT integration in EGD education. These findings will inform targeted strategies for professional development, curriculum support, and classroom innovation, thereby enhancing the effectiveness of teaching and learning in technology-enhanced EGD classrooms.

METHODOLOGY

This study employed a qualitative approach as it was deemed relevant because of its ability to gain greater and more in-depth insight about the phenomena. In contradiction to the quantitative research approach, qualitative research approaches focus on exploring and understanding individuals' deeper meanings, experiences, and perspectives through non-numerical data such as interviews and observations (Telly et al., 2022). This approach helped to uncover patterns and themes that reveal how people think and respond to the phenomena. Oranga and Matere (2023) argue that at its core, qualitative research asks open-ended questions whose answers are not easily quantifiable. The authors go on to posit that quantifying qualitative data is certainly possible, but

the essence of qualitative data is to establish patterns and themes that do not require quantification. Hence the approach this study used to uncover insights that may not be easily captured through quantitative measures, especially because the goal is to understand the teachers' attitudes and perceptions regarding the infusion of ICT in their teaching pedagogies. As such, data was collected from nine conveniently sampled Grade 10 and 11 teachers through interviews and classroom observations, one per school, totalling nine in all, as EGD is not a popular subject; hence, not every school offers it. Interview data was audio-recorded, transcribed, and analysed thematically. Thematic analysis is a highly popular technique among qualitative researchers for analysing qualitative data, which usually comprises descriptive data (Naeem et al., 2023). The classroom observations were done with nine EGD teachers after the interviews. This provided the researcher with a chance to collect information not available from the interviews. Koehler and Mishra (2009) adapted the classroom observation schedule from their TPACK framework. The researchers observed nine lessons, each conducted at a different school, to evaluate them against the three components of TPACK: Technological Knowledge (TK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). The researchers conducted all the observations in the teachers' classrooms, with each observation lasting an hour, a typical duration for most periods. The researchers had arranged the classroom observations with the intention of discovering teachers' technological knowledge and observing their attitudes when infusing ICT into their lessons. Observation method is described as a method to observe and describe the behaviour of a subject and it involves the basic technique of simply watching the phenomena until some hunch or insight is gained (Kumar and Sharma, 2023). Observations were chosen because they give a researcher a chance to directly study behaviour in a natural setting. The specific objectives were:

1. To understand EGD teachers' attitudes towards the adoption of ICT in EGD classrooms.
2. To understand EGD teachers' technological knowledge towards the use of technology in teaching and learning.

Table 1: Participants Profile

Name of teacher	Gender	Majors	Teaching Experience
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Teacher TnB	Male	EGD and Motor Mechanics	18 years
Teacher CcN	Female	EGD and Technology	11 years
Teacher ObR	Female	EGD and Mechanical Technology	9 years
Teacher RtW	Male	EGD and Technology	14 years
Teacher BmR	Female	EDG and Woodworking	25 years
Teacher OpD	Female	EGD, Mathematics and Woodworking	20 years
Teacher TrM	Male	EGD and Mechanical Technology	4 years
Teacher Ptw	Male	EGD	19 years
Teacher PbT	Female	EGD and Civil Technology	25 years

Table 1 contains a profile of teachers with pseudonyms, gender, teaching majors, and years of experience. All teachers specialise in EGD along with other subjects such as Motor Mechanics, Technology, Mechanical Technology, Woodworking, Mathematics, and Civil Technology. The teaching experience of the educators ranges from 4 to 25 years, indicating a mix of veteran and relatively novice teachers. The document provides a structured overview of their expertise, which can be useful for academic research.

All participating teachers from different schools in the uMgungundlovu circuit were selected as participants to gather information from both experienced and novice teachers with less experience. The participants were encouraged to share their perspectives in order to understand their perspectives on the infusion of ICT in EGD teaching pedagogies. All teacher participants gave their consent to be part of the study.

RESULTS AND DISCUSSIONS

The semi-structured interviews that were conducted with EGD teachers from nine different schools in the uMgungundlovu District provide responses to research objective 1, “*teachers attitudes towards the adoption of ICT in EGD classrooms*”.

Theme: ICT is critical in EGD teaching Pedagogies

The teachers perceive the integration of ICT in engineering teaching and believe that it has revolutionised the way students learn and interact with complex EGD teaching concepts. In their

response, teachers view ICT as pedagogy enablers that create immersive and interactive learning environments where learners can engage with 3D models, simulations, and animations, thereby enhancing their visualisation and understanding of complex EGD principles. Teacher TnB from school A mentioned,

One thing for sure you cannot run away from is technology because the world is evolving fast in terms of technology. And we are moving far away from the traditional way of doing things especially in EGD where ICTs can help learners to interact with 3D models to comprehend abstract EGD concepts. Technology is an integral part of teaching and learning.

In support, teacher CcN from school B said

Since EGD is a practical and abstract in nature, there is no other ways to reinforce certain concepts besides the use of ICTs. Learners struggle with spatial visualisation which can be developed when ITCs are used in our teaching pedagogies. However, the issue with my school is, we do not have many technologies which poses a challenge. We only use the chalkboard instruments which isn't sufficient.

Moreover, teacher PbT said

It is a good idea to infuse technology. Just that our Department of Education maybe they are out of funds because they have to fund every school because in order to infuse ICT, we need to have computer labs in every school.

The above claims clearly indicate that teachers see ICT as helpful partners in their EGD teaching pedagogies. However, they also perceive the absence of ICT tools in their schools as a barrier that impedes their efforts to incorporate these tools into their lessons. Moreover, teachers revealed that ICT tools, such as CAD software, help improve the accuracy of linework and reduce errors in drawings, allowing learners to focus on the creative aspects of problem-solving. In relation to this statement, Teacher QbR from another school said,

Teaching needs technology in lesson presentations, without technology teaching is impaired, because technology moves with time, so if we are training or raising a generation that must be competitive globally, they need ICT, they need technology, we just cannot divorce the two (technology and education). For example, I have been using Computer

Aided Design software as part of my teaching pedagogy which allow learners to be creative.

Clearly, these findings reveal the eagerness that teachers have in incorporating ICT in their EGD lessons. Even though there are some problems with integrating ICT, like limited infrastructure and resources, planning and carrying it out correctly can make a big difference in how well students learn and teach and ultimately preparing them for the needs of the modern engineering industry. The findings resonate with Kiwonde (2020)'s assertion that effective adoption and integration of ICT in teaching largely depends on the availability and accessibility of both hardware and software resources. ICT resources, including hardware, software, and technical support, need to be provided to teachers.

To respond to the research objective 2 “*EGD teachers’ technological knowledge towards the use of technologies in teaching and learning.*”

Theme: Teachers know how to use ICT

The teachers' response shows that their use of digital tools enhances their teaching methodologies and enriches student learning experiences. By integrating ICT into their lessons, teachers revealed that they employ a variety of software and online platforms that facilitate interactive and immersive learning environments, allowing learners to visualise complex engineering concepts and engage with design processes in real time.

Teacher RtW from school C said, “I do use technology when teaching EGD because there are a lot of things like graphics and drawings which learners must be able to see. This assist with the development of learners spatial visualisation skills which is a critical component to understanding EGD concepts.” This is because the use of learning technologies allows teachers to customise instruction to meet the unique needs of each learner, ensuring a personalised approach. However, conversely, another teacher, BmR from school D, mentioned, “I cannot say I have a challenge in using ICTs, it’s just that I do not have the correct equipment. Here at school, we do not have a projector, I have to buy it and a projector is very expensive”. In addition, teacher QpD from school E said, “In terms of AutoCAD, it is still a challenge because we know how to use AutoCAD, but you cannot put it in any computer. The computer that we have here at school does not support AutoCAD, which is unfortunate because AutoCAD promotes cooperative learning”.

This is in contradiction with the sentiments by Nyatiko et al. (2021) that teachers feel less confident in integrating ICT tools to which they were not exposed during their pre-service training.

The aforementioned sentiments indicate that teachers possess ICT skills, yet they face challenges because of a scarcity of resources. According to teachers, this technological integration facilitates student collaboration and fosters the development of spatial visualisation skills which is considered to be critical in EGD.

To address Research Objective 2 "*to understand EGD teachers' technological knowledge in relation to the use of technology in teaching and learning*", the following observations were made: A weak foundation in Technological Knowledge (TK) undermines the entire TPACK framework, as both Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) rely on a strong TK base.". They basically depend on TK.

Observations based on TK, TCK and TPK

Technological knowledge refers to the knowledge of various technologies, ranging from a pencil and paper to digital technologies such as the Internet of Things, digital video, interactive whiteboards, software programmes, robotics, artificial intelligence, and big data" (Koehler & Mishra, 2009). In this regard, the study is observing the knowledgeable part of using technologies. "Technological content knowledge looks at the relationship between technology and content knowledge about the subject matter" (Kurt, 2018). TCK also looks at how technology and content influence each other. Teachers need to understand which technologies are best suited for addressing the subject matter (Koehler & Mishra, 2009). "Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching and to the understanding that using technology may change the way teachers teach" (Koehler & Mishra 2009). Below are the observations from different teachers with respect to the components of TPACK, which are TK, TCK, and TPK.

Teacher TrM on TK: The TK component was observed through the use of a whiteboard and the computer. The teacher taught using the whiteboard very well. The researcher observed that teacher TrM was knowledgeable using technologies at disposal. He did not exhibit any kind of challenges when using a whiteboard, a computer to prepare worksheets, and printing them out. The researcher also believes that the teacher is knowledgeable when it comes to using a printer, and the prepared worksheets need to be printed out from the computer. The researcher can

conclude that teacher TrM displayed a high level of TK in using technologies that were at his disposal.

Teacher TrM on TCK: The teacher exhibited an understanding as far as choosing relevant technologies for the lesson that was conducted. The teacher selected a whiteboard, rather than a chalkboard, as the appropriate technology for a particular lesson. The researcher assumes that teacher TrM also used AutoCAD to prepare the worksheets. The learners used these worksheets as classwork. As far as the TCK is concerned, teacher TrM exhibited knowledge.

Teacher TrM on TPK: The teacher drew a sketch on the whiteboard using set squares and a marker. The teacher created the sketch to show the hatching. While drawing, the teacher showed levels of accuracy and called out some learners who had outstanding marks on his marksheet using a computer, and this showed the level of understanding to using a computer.

Teacher PtW on TK: The researcher observed that in Teacher PtW's classroom, there was a projector hanging from the ceiling and a whiteboard. Teacher PtW showed an understanding of these two technologies that were at his disposal. The teacher used both of these technologies in conjunction with the computer. The teacher showed no signs of struggle whatsoever. As a result, the researcher believes that the teacher's TK was strong.

Teacher PtW on TCK: The researcher observed that all the technologies that were used by teacher PtW were relevant to teaching the content of the day. It should also be mentioned that teacher PtW's class had no chalkboard, only two whiteboards for drawing and projector backgrounds. Teacher PtW was teaching interpretation, so at some point during the lesson, teacher PtW projected a video explaining how the interpretation occurs, which assisted learners in visualising the drawing much better. In addition, the teacher's projected video clearly articulated the fold lines and turning points. The worksheets given to learners were prepared before using AutoCAD, which showed that the teacher's choice of technology was relevant to the content being taught and was exceptional. Based on this observation, the researcher believes that teacher C's TCK was exceptional as long as the technologies used assisted the learners in understanding the topic better.

CONCLUSIONS

The findings of this study underscore the critical role of Information and Communication Technologies (ICT) in enhancing pedagogical practices within the Engineering Graphics and Design (EGD) subject. Teachers view ICT as not just supplementary, but as an essential pedagogical enabler that transforms the teaching and learning of complex spatial and abstract concepts. The integration of digital tools such as CAD software, simulations, and projectors contributes to more engaging, interactive, and visually immersive learning environments, aligning directly with the Technological Pedagogical and Content Knowledge (TPACK) framework. The study found that teachers possess a solid foundation in Technological Knowledge (TK), with many demonstrating fluency in using available tools such as computers, projectors, and whiteboards to support lesson planning and delivery. This technological fluency is critical, as it forms the base upon which both Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) are built. Without sufficient TK, teachers cannot effectively integrate technology into content delivery or adjust their pedagogical strategies to suit a technology-rich environment.

In terms of TCK, the study showed that teachers are able to select and utilise technologies that are well-suited to conveying EGD content, such as using AutoCAD to reinforce technical drawing skills or videos to explain spatial relationships. These practices enhance learners' understanding and retention of abstract principles, especially in areas where traditional teaching tools are insufficient. Teachers demonstrated their ability to align technological tools with curriculum needs, thereby reinforcing the synergistic relationship between technology and content. From a TPK perspective, teachers displayed awareness of how technology transforms instructional delivery. The use of videos, simulations, and digital presentations allowed teachers to adapt their pedagogical approaches to foster greater student engagement and improved visualisation of EGD concepts. Observations further highlighted how ICT integration allows for differentiated instruction and the development of spatial visualisation skills, which are central to success in EGD. Despite these positive outcomes, the study also highlighted persistent barriers, including limited access to infrastructure and technological resources in many schools. Teachers expressed frustration at the lack of computer labs, insufficient hardware, and outdated equipment that hinder the full realisation of ICT's potential in their classrooms. This gap between knowledge and

implementation emphasizes the importance of systemic support and resource allocation by education departments.

In integrating the study's findings with the TPACK framework, it becomes evident that while many teachers possess the necessary knowledge across the TK, TCK, and TPK domains, their ability to operationalise this knowledge is often constrained by external factors. Addressing these infrastructural limitations is essential to unlocking the full potential of ICT in EGD education. Furthermore, the findings reinforce that effective ICT integration is not solely a matter of technological access, but also of the informed, strategic interplay between technology, pedagogy, and content. Ultimately, the TPACK framework provides a comprehensive lens through which to understand the multi-dimensional nature of ICT integration in EGD. By highlighting the competencies and challenges faced by teachers, this study offers valuable insights for policymakers, curriculum developers, and educational stakeholders aiming to foster technologically enriched, student-centred learning environments that prepare learners for the demands of the modern, technology-driven engineering industry.

RECOMMENDATIONS

Therefore, based on the analysis of the study's findings through the lens of the TPACK framework, several recommendations are proposed to enhance the integration of Information and Communication Technologies (ICT) in the teaching of Engineering Graphics and Design (EGD). Firstly, there is a critical need for the Department of Basic Education to improve ICT infrastructure in schools, particularly by providing computer labs, projectors, updated hardware compatible with specialised software like AutoCAD, and stable internet connectivity. Many teachers expressed a willingness to incorporate ICT but were hindered by a lack of basic resources. Secondly, structured and ongoing professional development should be offered to enhance teachers' Technological Knowledge (TK) and support the effective use of these tools within their pedagogical practices (TPK) and subject content (TCK). Incorporating TPACK-based training into both pre-service and in-service teacher education programmes is also essential to prepare teachers for technology-enhanced instruction. Additionally, the development and dissemination of digital teaching materials, such as CAD tutorials, instructional videos, and interactive simulations should be prioritised to support teachers in delivering visually and conceptually rich EGD content. To encourage continuous growth and collaboration, schools should establish professional learning

communities (PLCs) where teachers can share best practices and co-develop technology-integrated lesson plans. Furthermore, policymakers must address disparities in ICT access by ensuring equitable distribution of resources across all schools, especially in under-resourced areas. Finally, regular monitoring and evaluation of ICT usage in EGD classrooms should be implemented to assess the effectiveness of integration efforts, identify ongoing challenges, and inform data-driven improvements. These recommendations collectively aim to support a more effective, inclusive, and sustainable approach to ICT integration in EGD classrooms.

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