Journal of Education and Teaching (JET)
Vol. 7 No. 1 2026

Digital Technology Integration in Engineering Graphics and Design Education: A Qualitative Study of Teachers' Pedagogical Practices and Challenges

Lutho Mteleli[1], Thokozani Isaac Mtshali[2], Ndlelehle Skosana[3]
Technology and Vocational Education, Tshwane University of Technology, South Africa[1,2,3]
Corresponding Email: lutomteleli@gmail.com

Draft article history
Submitted: 08-31-2025;
Revised: 01-11-2026;
Accepted: 01-12-2026;

ABSTRACT: This study investigates the use of digital and educational technology tools in Engineering Graphics and Design (EGD) lessons in response to the Department of Education's call for effective technology integration in schools. The study addresses a knowledge gap regarding how EGD teachers utilise available technologies to achieve intended learning outcomes, while also examining the challenges, successes, and pedagogical strategies involved. A qualitative research design was employed, using semi-structured interviews, non-participant classroom observations, and equipment analysis. Purposive sampling was used to select six EGD teachers and seventy-two learners. Guided by the Technological Pedagogical Content Knowledge (TPACK) framework and constructivist pedagogy, the findings reveal that teachers commonly used smart boards, projectors, and internet-based resources to support demonstrations and visualisation of complex drawings. However, technology integration remained largely supplementary rather than transformative, as digital tools were often used only after traditional lecture-based instruction. The study concludes that EGD teachers have not yet fully integrated technology into lesson planning and delivery. It recommends targeted professional development to promote transformative digital pedagogy and continuous reflective teaching practices.

Keywords: engineering graphics and design, information and communication technology, ICT integration, transformative teaching methods

ABSTRAK: *Penelitian ini mengkaji penggunaan alat teknologi digital dan pendidikan dalam pembelajaran Engineering Graphics and Design (EGD) sebagai respons terhadap seruan Departemen Pendidikan untuk mengintegrasikan teknologi secara efektif di sekolah. Penelitian ini bertujuan mengisi kesenjangan pengetahuan terkait cara guru EGD memanfaatkan teknologi yang tersedia untuk mencapai capaian pembelajaran, sekaligus mengkaji tantangan, keberhasilan, dan strategi pedagogis yang diterapkan. Penelitian ini menggunakan pendekatan kualitatif dengan metode pengumpulan data berupa wawancara semi-terstruktur, observasi kelas non-partisipan, dan analisis perangkat. Teknik purposive sampling digunakan untuk memilih enam guru EGD dan tujuh puluh dua peserta didik. Penelitian ini dipandu oleh kerangka Technological Pedagogical Content Knowledge (TPACK) dan pedagogi konstruktivis. Hasil penelitian menunjukkan bahwa guru EGD umumnya menggunakan papan pintar, proyektor, dan sumber berbasis internet untuk mendukung demonstrasi dan visualisasi gambar teknik yang kompleks. Namun, integrasi teknologi masih bersifat suplementer dan belum transformatif karena alat digital sering digunakan setelah pembelajaran berbasis ceramah. Penelitian ini menyimpulkan bahwa guru EGD belum sepenuhnya mengintegrasikan teknologi dalam perencanaan dan pelaksanaan pembelajaran, serta merekomendasikan pengembangan profesional berkelanjutan untuk mendorong pedagogi digital yang transformatif dan praktik reflektif.*

Kata kunci: engineering graphics and design*, teknologi informasi dan komunikasi, integrasi TIK, metode pembelajaran transformatif.*

INTRODUCTION

Due to its complext nature of concepts, EGD remains one of the most challenging learning subjects in the technology and vocational space (Maeko, 2025). The need for meticulous use of drawing tools and the strategic handling of drawing instruments makes the total conception of the subject somewhat challenging for learners (Mlambo & Sotsaka, 2025).The greatest thread lies on its absence of narrative and depending on sketches and various engineering drawings to communicate (Candiotes, Rauscher & Van Putten, 2025). Learners do not always find it easy to understand drawings without narratives and that becomes a huge task for teachers to accomplish. It is for this reason that educational tools such as smartboards should be used to assist teachers and learners to understand better (Ngcobo, 2025). However, there is a gap in knowledge on how effective are teachers in using various educational technologies to teach EGD concepts and this study sought to close this gap.

According to Mtshali and Sephokgole (2025) teaching Engineering Graphics and Design (EGD) has been increasingly demanding the use of educational tools due to drawing concepts such as assembly and civil drawings. Some studies have discovered that teachers fail to develop visual and spatial skills in learners (Badmus & Jita, 2022; Singh-Pillay & Sostaka, 2016). This is attributed to the use of ineffective teaching techniques, where a teacher merely emphasizes the construction of lines rather than developing the spatial structures of learners. It is for this reason that the Department of Basic Education (DBE) saw it fitting to equip schools with educational technologies such as laptops, overhead projectors and smartboards to assist teachers in deliverying meanigful lessons that are rooted on leaner outcomes (Ndlovu et al., 2025). This study took an opportunity to explore on the success of those educational technolgies in teaching EGD lessons in selected schools in the Limpopo province.

Actualising spatial visual skills is empirial in the EGD lessons (Wang, 2023). For instance, learners do not always have motor mechanics knowledge or knowledge about house and site plans. Therefore, it becomes the teacher's responsibility to put learners into that meta-cognitive reality (Di & Zheng, 2022). In essence, EGD is a subject that requires learners to think creatively and develop practical skills and also be able to communicate engineering ideas (Mthethwa, 2024). And so, digital tools can play a very crucial role in helping learners develop those creative and critical thinking skills required in EGD. It has been discovered by Sibiya et al. (2025) that using overhead projectors to teach graphical communications speeds up conception among senior phase technology learners. This implies that there could be benfits that can be sought from the varied educational tools, especially where teaching EGD to further educationa and training phase learners.

Mhlanga, Denhere and Moloi (2022) affirms that since the abrupt change to online learning in most educational institutions in 2020, teaching with technology is fast becoming the classroom every teacher hopes to have. The

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

effective integration of ICT tools in EGD classrooms requires teachers to have skills and confidence to be able to use these tools effectively. In agreement, Lionenko and Huzar (2023) emphasises that teacher's confidence in blending digital technologies with subject content is key to meaningful curriculum delivery in subjects like EGD. Although the DBE encourages teachers to use digital resources during teaching and learning, much is needed to accelerate this practice (Mollo, 2022). For example, continous curriculum review that is centred on digitisation of education and sufficient infrastructure (Timotheou et al., 2023).

Using educational technologies EGD lessons is crucial in that the subject mainly focuses on line work, accuracy, and neatness and these can be best explained by visuals and motion pictures (Roman & Iryna, 2024). In agreement, Mlambo, Maeko and Khoza (2023), confirms that these various skills range from spatial skills to the visualization of abstract concepts to the understanding of different types of lines used in EGD. Contextual factors such as resource availability, teaching practices, and institutional culture significantly shape how digital tools are integrated and implemented in technical schools (Masingi, 2024). Teachers need to be able to design engaging and interactive lessons that incorporate digital tools in a meaningful way. Yet, many EGD teachers may not have the necessary skills and confidence to integrate them into their teaching and learning. Mtshali, Ramaligela, and Makgato (2020), affirms that a disparity exists between the current availability and utilization of digital technology resources for instructional purposes. And so, how do teachers continue to enact transformative teaching methods amidst these challenges? Therefore, to understand how teachers utilize various digital tools provided by the DBE officials and the digital skills they posses need further exploration, and this study sought to close this gap.

To reiterate, there is a need for research on how EGD teachers integrate digital tools in their classrooms, including the types of educational technology tools used, the methods used for the integration, and also the challenges and benefits associated with them. Indeed, there has been proposed solutions to this effect which include ongoing training and support for EGD teachers to build confidence and competence in using interactive tools and collaborative support network. However, Limpopo province schools present a unique infrastructural enviroment and learning culture which cannot be overlooked by generalised solutions. Thus,it is important to explore the use of such tools in a unique and rural infrastructural and socio-economic environment to ensure that digital education adaptation is not merely policy-driven but pedagogically meaningful as well.

Conceptual Framework

To explore explored the use of educational technology tools in Engineering Graphics and Design (EGD) lessons, this study used Mishra and Koehler (2006) Technological Pedagogical Content Knowledge (TPCK) model and Piaget (1972) foundational concept of constructivist pedagogy. Using these frameworks allows for the understanding of the issue under scrutiny. Accroding to Mishra and Koehler (2006) TPCK framework which is now renamed as TPACK assist in understanding

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

teacher knowledge required for effective technology integration (Mishra & Koehler, 2006). Since this study was concerned with understanding how EGD teachers used educational technology tools in their lessons, TPACK guided the researchers to understand teachers Technological Knowledge, Content Knowledge, and Pedagogical Knowledge.

According to Mishra and Koehler (2006) Technology knowledge (TK) refers to the knowledge about various technologies such as digital technologies (i.e. Internet, digital video, interactive whiteboards, and software programs). This study used TK to understand how teachers use educational technology tools to teach EGD lessons. Alhiane and Nafidi (2026) posit that Content Knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026). This study used CK to ascertain if teachers know about the content of EGD and the concepts they were teaching. Pedagogical knowledge (PK) is known as a method and process of teaching which includes knowledge on promotion of classroom culture of learning. This study used PK to evaluate how EGD teachers created a teachable enviroment through the use of various teaching strategies.

This study also used Constructivist pedagogy which is known as a learner-centered approach where learners are active in building their own understanding, meaning and knowledge of the world they are experiencing (Chand, 2026; Piaget, 1972). Therefore, this study used constructivist pedagogy to understand how teachers create opportunitiy for leaners to learn through and with their peers. The use of these theories assisted to discuss and analyse data through scientific lenses. Furthermore, this theoretical stance underscores the importance of transformative teaching methods that not only deliver content but also cultivate problem-solving, critical thinking and adaptability in a rapidly evolving digital world.

METHODs

A qualitative research approach was used to explore how EGD teachers in the Limpopo Province integrate ICT tools into their teaching and learning, capturing both practices and challenges. This approach allows for in-depth understanding of teachers' lived experiences, beliefs, perceptions, and challenges regarding the use of educational tools to teach EGD lessons (Tuffour, 2017). As a result, this study adopted a phenomenological research design to understand the lived experiences and the unique meanings EGD teachers attributes to the phenomenon of teaching using educational technology tools (Norlyk & Harder, 2010).

Population and Sample

The population of this study comprises of all EGD teachers in public secondary schools in the Limpopo Province. Given the practical limitations of engaging the whole population, a purposive sampling technique was used to select participants who have direct experience teaching EGD using traditional teaching methods and those who have exposure to educational technology tools. According

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

to Tajik, Golzar and Noor (2025) purposive sampling allows researchers to intentionally select information-rich participants based on a set criteria relevant to the study's goals, and so, this study only selecrted EGD teachers who could offer in-depth understanding and expertise of the unique knowledge bieng sought. Therefore, this study purposively sampled six EGD teachers and a total of seventy-two (72) learners drawn from diverse school contexts (rural areas, townships and urban areas) to ensure variability and rich insights.

Data Collection Technique

Various data collection techniques were used to collect relevant data in this study which included classroom participation observations, semi-structured interviews and equipment analysis. This was to allow triangulation of data to strengthen its trustworthiness (Natow, 2020). Therefore, classroom observation was used to capture teachers' actual pedagogical practices in action, focusing on the tools used and how they were used. In keeping with Bell et al. (2019) classroom observation guide, classroom observation was used to evaluate teaching quality and observe how effective was curriculum delivery using digital and educational technology tools. The purpose of using semi-structured interviews was to ascertain the reasons behing what was observed, For example, it was important for the researcher to understand why some EGD teachers used educational technology tools after they have taught using lecture method. Additionally, equipment analysis was used to analyse the availability of educational technology resources such as smartboards, projectors, and laptops. Moreover, the interest was whether they were functional or remained in the classrooms while they were broken.

Data Analysis Technique

Thematic analysis was employed to analyse the qualitative data. Following Braun and Clarke's (2021) six-phase model, the data was transcribed, coded, categorized, and interpreted into themes that align with the research's objectives. Data was coded to identify key themes and categories regarding challenges, benefits, and strategies for technological integration. The analysis paid special attention to identifying patterns in ICT integration strategies, challenges, and opportunities within EGD classrooms. Trustworthiness was ensured through credibility, dependability, confirmability. For instance, the credibility of the findings was ensured by employing a checking technique whereby transcribed data was taken back to participants to confirm that it was a true reflection and interpretation of their inputs (Bryman & Bell 2007). To ensure credibility still further, the study triangulated the collected data. According to Bryman (2007), triangulation means that data instruments are mixed so that they subject what is being researched to greater scrutiny in order to optimise the findings. In terms of confirmability**,** the researchers were non-participant observers in this study, hence they were able to exercise objectivity when reporting the data. As a result, they did not allow their personal views to influence the carrying out of the research or the results flowing from it (Bryman & Bell 2007). For dependability, all

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

the recorded data was treated confidentially. The consolidated data is still known only to the research team, that is, the principal researcher and her supervisors (Creswell, 2013). Hard copies and all the audio-visual material are kept safe at the Tshwane University of Technology and this will be discared after five years.

RESULTS AND DISCUSSIONS

This study explored the use of educational technology tools in Engineering Graphics and Design (EGD) lessons. The findings of this study were derived from classroom observations, semi-structured interviews and equipment analysis. When exploring how teachers taught EGD lessons, this study discovered that these selected teachers used: 1) Various educational technology tools; 2) Traditional lecture method. The abovementioned themes are presented in detail below.

Educational tools for EGD lessons

Across the schools observed, some teachers demonstrated varying levels of use in the provided educational technologies. Teacher A below used a document camera which assisted learners to see how the drawing was done, the handling of drawing tools and the use of line types in real time, see the extract below.

Figure 1. Teacher A's lesson

While the above extract shows a teacher explaining a drawing concept, it is important to state that this happened just after he was done explaining the actual drawing on the chalkboard. When asked why he was now teaching using the document camera, he said that

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

"Whenever I see that my learners are having a challenge in drawing, I show them how to measure, mark points and how to use a compass. This makes it easy for them to continue with the drawing task"

Teachers B used an overhead projector to show leaners how to draw floorplan which are part of civil drawings, see the excerpt below:

Figure 2. Teacher B's lesson

As shown above, Teacher B drew and the learners were looking at the projected drawing and followed the teacher on each drawing step. Another teacher who used his educational technology tools was teacher C, see the excerpt below

Figure 3. Teacher C's lesson

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

As shown on the figure above, the teacher used a software to demonstrate how the learners were supposed to draw the loci of a cam. She used a software to show the learners the steps they were supposed to follow in order to draw loci of a helix, and she projected that on the projector screen. Interstingly, the teacher had also tried to show leaners on the whiteboard how to start drawing a loci helix. When asked why she projected a complete drawing she said

> "*These leaners are now used to me showing them a complete drawing because some cannot see clearly on what i have drawn using drawing pen, sometimes the ink is not visible for those who are at the back of the classroom*"

While there some of the teachers took advantage of the technological resources avaialble is class, there were those who did not have them but used a different way of teaching and the follwing theme unpacks them.

Traditional lecture method

It must be noted that during equipment analysis, the researcher had determined that Teacher D had no educational technology tools that existed in his classroom. Figure 4 below displays how Teacher D taught the concepts of solid geometry, see extract below:

Figure 4. Teacher D's lesson

As reflected on the above figure, learners were modelled on how to create points from the original drawing in order to come up with a true shape. As a norm in so many EGD classrooms, learners keep quiet and follow the drawing steps just

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

as their teacher did. Indeed, this is not ideal because if a teacher makes a drawing step mistake, all learners will follow that particular step.

Another teacher who did not use any educational technology tools was Teacher E, see figure 5 below.

Figure 5. Teacher E's classroom

It is good to meantion that while Teacher E used only a chalkborad, his drawing were clear when viewed at the back of the class. He used real drawing instruments to show leaners how to draw a sectional elevation. Even when he taught lower grades,he used set-squares to draw on the chalkboard. However, to strnghten the linework, he could have used different colours to enhance meaning of sections in the drawing. All other participants used chalkboards and their pedagogical practices were similar to that of Teacher E.

Discussion

As a reminder, this study was concerned with how teachers taught EGD lessons. The findings of this study reveal that some teachers demonstrated some level of expertise in the core knowledge areas of TPACK. For instance, when it comes to Content Knowledge (CK), all teachers demonstrated acceptable knowledge levels about the subject matter (EGD concepts). According to Kholid et al. (2023) the general challenges about content knowledge among teachers could involve the lack of deep subject matter expertise, leading to misconceptions in learners, insufficient resources, and pressure to meet curriculum demands. In the case of these teachers, none displayed any challenge to teach, even teachers D to F who did not have sufficient resources, they could still teach EGD concepts using their limited resources.

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

In terms of Pedagogical Knowledge (PK), this study found that the overeliance on lecture method by the mojority of teachers indicates weakness in using transformative teaching methods, instructional strategies and classroom management. A study by Su et al. (2023) when they explored Artificial intelligence literacy in early childhood education, they too found that teachers sufficient pedagogy to transfer AI knowledge and skills as well as lack of curriculum design and teaching guidelines. The same could be inferred to the sampled teachers. For instance, Teacher C had shown learners a complete drawing becuase he could not teach it effectively on a whiteboard (see figure 3). When it comes to Technological Knowledge (TK), this study found that Teachers A to C were familiay with digital tools and resources. In a study by Msimango and Mtshali (2025) when exploring the feasibility of a learner-centered approach in a civil technology classroom, they discovered that most teachers whose schools have functioning digital tools, are competent in TK. The same judgement applies into these teachers as they used smart boards, projectors, and videos, which enhanced leaners visual and spatial skills, and it also transformed teaching and learning.

When zooming into the constructivist lense, this study found serious challenges on the side of teachers. This is becuase a constructivist pedagogy is understood to be a learner-centered teaching approach where learners actively build their own understanding and knowledge through experiencing things and reflecting on those experiences, rather than passively receiving information (Naidoo & Mabaso, 2023). These teachers (especially Teacher A to E) had not in anyway promoted learner centredness in their pedagogical practices. The showed leaners how to draw and made leaners to follow their steps, even when a mistake in drawing was made, only the teacher could fix it in the front (refer to figure 1). Even how Teacher A responded when asked about the need to use document camera, he said that he use it when he has identified a drawing challenge among his learners. Mtshal (2023) advises against this practice and called for all EGD teachers to promote classroom discourse in order to eliminate all possible drawing misconceptions during the lesson phases.

Holistically, the results suggest that tbhe use of educational technology tools in EGD is still nascent and uneven. While teachers recognize digital technology potential to enhance visualization and contextualization, systemic barriers hinder its transformative use. The emphasis on learner participation and digital drawing platforms reveals a pedagogical appetite for change, though this remains constrained by resource and training gaps. While teachers display strong content and pedagogical knowledge, their limited technological knowledge reflects a gap that could be filled through targeted professional development (Khoza, 2017). The integration of digital drawing platforms could transform EGD from a subject of technical replication to one of creative, industry-aligned learning. Such a shift aligns with the demands of the Fourth Industrial Revolution and could prepare learners for higher education and professional practice in engineering and design.

CONCLUSION

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

As the study explored how EGD teachers taught using educational technology tools in their lessons, the findings revealed that EGD teachers commonly used digital tools such as smart boards, projectors, and Wi-Fi for videos to support demonstrations, visualising complex drawings, and connecting concepts to real-life problems. However, the integration remained largely supplementary rather than transformative in some schools. This is because teachers used the technological tools only after concluding a lesson using a lecture method. Therefore, this study concludes that EGD teachers do not actively used educational technology tools for planning and teaching their lessons rather they use them as means to help cover the remainder of the lesson. This study recommends that teachers should be taught how to plan and teach their EGD lessons using digital tools in order to preserve all teaching, learning and assessment evidence. This will ultimately ensure that teachers reflect on their practices and improve on their lesson delivery continuously.

Furthermore, the findings revealed that while teachers do incorporate digital tools, their use are largely limited to basic applications such as PowerPoint presentations, videos, and digital drawings, rather than advanced design software or interactive platforms. In some schools, teachers had limited access to functional digital and educational resources, unreliable infrastructure, insufficient technical support, lack of training in subject-specific ICT applications and low confidence in adapting technology for complex EGD concepts. These factors collectively constrain ICT from being fully embedded into teaching and learning. Therefore, this study recommends for ongoing professional development tailored to EGD, improved infrastructure provision and maintenance, and collaborative support structures where educators can share digital resources and best practices amongst each other in their workshop. Such interventions would not only enhance ICT integration but also improve learners' conceptual understanding and engagement with EGD. Based on the overall constructivist pedagogical challenge, this study recommends that the Department of Education could revise its content policies by breaking down complex technical drawings into smaller, manageable steps to scaffold learners' understanding. Using digital tools would make this easier because they can zoom in on details. Group work could also be used as a strategy to encourage collaboration and peer learning. Additionally, this study recommends the compulsory introduction of basic digital drawing platforms (such as CAD software) to make EGD more interactive and aligned with professional industry practices.

ACKNOWLEDGEMENT

The author would like to thank the EGD teachers who volunteered to form part of this study. Also the supervisor and co-supervisor for their guidance and support in the completion of this study.

REFERENCES

Alhiane, M., & Nafidi, Y. (2026). Integrating Intelligent-Technological Pedagogical and Content Knowledge (Intelligent-TPACK) and Tripartite Models to

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

Examine Teachers' Knowledge and Attitudes Toward Artificial Intelligence (AI). *ASEAN Journal of Educational Research and Technology*, *5*(2), 229-244. https://ejournal.bumipublikasinusantara.id/index.php/ajert/article/view/845

Badmus, O. T., & Jita, L. C. (2022). Pedagogical ımplication of spatial visualization: A correlate of students' achievements in physics. *Journal of Turkish Science Education*, *19*(1), 97-110. https://doi.org/10.36681/tused.2022.112

Bell, C. A., Dobbelaer, M. J., Klette, K., & Visscher, A. (2019). Qualities of classroom observation systems. *School effectiveness and school improvement*, *30*(1), 3-29. https://doi.org/10.1080/09243453.2018.1539014

Braun, V., & Clarke, V. (2020). What counts as quality practice in (reflexive) thematic analysis? Qualitative Research in Psychology, 17(2), 1–25.

Bryman, A. & Bell, E. (2007). Business Research Methods. New York, Oxford University Press.

Candiotes, V., Rauscher, W., & Van Putten, S. (2025). A repurposed geometric reasoning model for Engineering Graphics and Design: a conceptual paper. *Design and Technology Education: An International Journal*, *30*(3), 100-121. https://doi.org/10.24377/DTEIJ.article3352

Chand, S. P. (2026). Constructivism in theory and practice: implications for classroom pedagogy. *Journal of Advanced Education and Sciences*, *6*(1), 23–29. https://doi.org/10.64171/JAES.6.1.23-29

Chigona, A. (2017). Teachers' understanding of technology usage in rural South African schools. Frontiers in Education, 10, 1548457.

Creswell, J. W. (2013). Qualitative Inquiry and Research Design: Choosing Among Five Traditions (3rd ed.). Thousand Oaks, CA: Sage Publications. https://lccn.loc.gov/97004820

Di, X., & Zheng, X. (2022). A meta-analysis of the impact of virtual technologies on students' spatial ability. *Educational technology research and development*, *70*(1), 73-98. https://doi.org/10.1007/s11423-022-10082-3

Kholid, M. N., Hendriyanto, A., Sahara, S., Muhaimin, L. H., Juandi, D., Sujadi, I., ... & Adnan, M. (2023). A systematic literature review of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education: Future challenges for educational practice and research. *Cogent education*, *10*(2), 2269047. https://doi.org/10.1080/2331186X.2023.2269047

Lionenko, M., & Huzar, O. (2023). Development of critical thinking in the context of digital learning. *Economics & Education*, *8*(2), 29-35. https://doi.org/10.30525/2500-946X/2023-2-5

Maeko, M. S. A. (2025). English teachers' perspectives on infusing ICT in Engineering Graphics and Design pedagogies using the TPACK framework. African Journal of Online and Distance Education, 10(1), 1–15. https://doi.org/10.21083/ajote.v14i1.8334

Masingi, J. (2024). Contextual factors, instructional practices, and challenges in integrating ICT in EGD teaching in Polokwane's selected technical schools. International Journal of Education and Business, 7(1), 23–34.

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

Mhlanga, D., Denhere, V., & Moloi, T. (2022). COVID-19 and the key digital transformation lessons for higher education institutions in South Africa. Education Sciences, 12(7), Article 464.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teachers' knowledge. Teachers College Record, 108(6), 1017–1054. http://www.tpack.org/

Mishra, N. R. (2023). Constructivist approach to learning: An analysis of pedagogical models of social constructivist learning theory. *Journal of research and development*, *6*(01), 22-29. https://doi.org/10.3126/jrdn.v6i01.55227

Mishra, P., & Koehler, M. J. (2020). Revisiting technological pedagogical content knowledge: What 12 years of TPACK research tells us. Journal of Education and Information Technologies, 25(4), 1–22.

Mlambo, P. B. (2023). Teachers' readiness towards the integration of information and communications technology in teaching and learning of engineering graphics and design in KwaZulu-Natal. Research in Social Sciences and Technology, 13(2), 1–15.

Mlambo, P. B., & Sotsaka, D. T. S. (2025). Exploring synergies in Euclidean geometry and isometric drawing: A snapshot on grade 12 mathematics and engineering graphics & design. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(4), em2617. https://doi.org/10.29333/ejmste/16172

Mlambo, V., Maeko, T., & Khoza, S. D. (2023). Teachers' feedback practices and their role in promoting transformative learning in South African classrooms. South African Journal of Higher Education, 37(4), 112–126. https://doi.org/10.20853/37-4-5659

Mollo, N. T. (2022). Continuous Professional Teacher Development Within an Online Teaching Context: An Education Law And Policy Perspective. *Journal of Educational Studies*, *2022*(si1), 52-68. https://hdl.handle.net/10520/ejc-jeds_v2022_nsi1_a4

Msimango, S. M., & Mtshali, T. I. (2025). The feasibility of a learner-centered approach in a civil technology classroom. *Journal of Education and e-Learning Research*, *12*(4), 763-769. https://ideas.repec.org/a/aoj/jeelre/v12y2025i4p763-769id7899.html

Mthethwa, S. E. (2024). An Artist within, brings out the Drawing in Class: A Creative Approach to Teaching and Learning Engineering Graphics and Design. E-Journal of Humanities, Arts and Social Sciences (EHASS), Volume 5(16), pp 3247-3256. https://doi.org/10.38159/ehass.202451644

Mtshal, T. I. (2023). Students Metacognitive Challenge in the Interpretation of Mechanical Drawings in Engineering Graphics and Design. Journal of Positive Psychology and Wellbeing, 7(4), 189-203.

Mtshali, T., & Sephokgole, D. (2025). Learning To Teach Orthographic Drawing (Sketching) By Preservice Teachers: A Probe Into A Method That Works For Students In Engineering Graphics And Design. In *EDULEARN25 Proceedings* (pp. 3185-3189). IATED.

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

Mtshali, T. I., Ramaligela, S. M., & Makgato, M. (2020). Usage of digital resources in Civil Technology: A case of teaching Tools and Equipment. *African Journal of Science, Technology, Innovation and Development*, *12*(1), 47-55.

Naidoo, D., & Mabaso, M. (2023). Social constructivist pedagogy in business studies classrooms–teachers' experiences and practices. *Perspectives in education*, *41*(2), 62-76. https://hdl.handle.net/10520/ejc-persed_v41_n2_a6

Natow, R. S. (2020). The use of triangulation in qualitative studies employing elite interviews. *Qualitative research*, *20*(2), 160-173. https://doi.org/10.1177/1468794119830077

Ndlovu, L. K., & Mtshali, T. I. (2025). Tablet adoption and mobile learning impact in high school. Jurnal Inovasi Teknologi Pendidikan, 12(3), 287–297. https://doi.org/10.21831/jitp.v12i3.88985

Ngcobo, Z. (2025). Keeping Pace with 21st Century Skills: The Role of Computer-Aided Design in Teaching Engineering Graphics and Design. International Journal of Learning, Teaching and Educational Research, 24(12):546-568. https://doi.org/10.26803/ijlter.24.12.24

Norlyk, A., & Harder, I. (2010). What makes a phenomenological study phenomenological? An analysis of peer-reviewed empirical nursing studies. *Qualitative health research*, *20*(3), 420-431. https://doi.org/10.1177/1049732309357435

Piaget, J. (1972). Psihologie și pedagogie. *București: Editura didactică și pedagogică*.

Ramatsetse, B., Daniyan, I., Mpofu, K., & Makinde, O. (2023). State of the art applications of engineering graphics and design to enhance innovative product design: a systematic review. *Procedia CIRP*, *119*, 699-709.

Roman, S., & Iryna, S. (2024, May). Features Of Using Computer Graphics Under Conditions Of Distance Learning In Vocational (Vocational And Technical) Education Institutions. In *The 19th International scientific and practical conference "Creative business management and implementation of new ideas"(May 14–17, 2024) Tallinn, Estonia. International Science Group. 2024. 281 p.* (p. 145).

Sibiya, M. T., & Mtshali, T. I. (2025). Teaching Graphic Communication and Techniques to senior phase Technology learners: A guide for teachers. *International Journal of Education and Teaching Zone*, *4*(2), 195-207.

Singh-Pillay, A., & Sotsaka, D. S. (2016). Engineering graphics and design teachers' understanding and teaching of assembly drawing. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(5), 1213-1228. https://dx.doi.org/10.12973/eurasia.2017.00668a

Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial intelligence (AI) literacy in early childhood education: The challenges and opportunities. *Computers and Education: Artificial Intelligence*, *4*, 100124. https://doi.org/10.1016/j.caeai.2023.100124

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)

Tajik, O., Golzar, J., & Noor, S. (2025). Purposive sampling. *International Journal of Education & Language Studies*, 1-9. https://doi.org/10.22034/ijels.2025.490681.1029

Timotheou, S., Miliou, O., Dimitriadis, Y. et al. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. Educ Inf Technol 28, 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Tuffour, I. (2017). A critical overview of interpretative phenomenological analysis: A contemporary qualitative research approach. *Journal of healthcare communications*, *2*(4), 52.

Corresponding author: Lutho Mteleli (lutomteleli@gmail.com)