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THE CENTRALITY OF ENGINEERING GRAPHICS AND DESIGN IN STUDYING TECHNICAL SUBJECTS: A CASE OF A UNIVERSITY OF TECHNOLOGY IN KWAZULU-NATAL

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Abstract

This mixed-methods study aimed to investigate the centrality of Engineering Graphics and Design (EGD) in technical subjects. Since the introduction of the technical stream, EGD has consistently been one of the compulsory subjects that learners are required to take alongside other trade subjects such as Civil Technology, Electrical Technology, and Mechanical Technology. However, in recent times, some teacher training universities have decided to remove EGD from the list of compulsory subjects for pre-service teachers pursuing the technical stream, a decision that has sparked a range of mixed reactions. Consequently, this necessitated an enquiry through employing purposive sampling to select five technical lecturers in the school of education to gauge their insights. Data were collected through open-ended questionnaires and Civil Technology test scores from 56 pre-service teachers. Test scores were analysed descriptively using Statistical Package for Social Sciences (SPSS) version 30 and open-ended questionnaires were analysed thermically. The findings suggest that EGD is very significant to pre-service teachers in the technical stream. This is based on the analysis that revealed that pre-service teachers doing EGD performed better compared to their counterparts in a Civil Technology test. Findings further reveal that lecturers believe EGD should be mandatory for pre-service teachers undertaking technical subject, as it provides foundational knowledge for drawing-related topics covered. Based on this, the study recommends that all pre-service teachers enrolled in the technical stream should be required to take EGD in their first year of study to ensure they acquire essential drawing skills relevant to their field.

Keywords **–** Engineering graphics and design, Technical subjects, Graphical communication, Civil technology, Lecturers.

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1. Introduction

Educational institutions are designed to cater for a larger diverse population that possess different skills hence training should also be tailor made for such. It is very imperative that learners know exactly what they aspire to be so that they get training that aligns with their aspirations. For instance, learners who aspire to pursue careers in engineering related fields they should lean towards technical stream which is a pathway within the curriculum that focuses on practical, vocational, and technical skills, often leading to careers in skilled trades or technical fields. Within the technical stream there are several *"technical subjects"* such as the Engineering Graphics and Design (EGD) which is introduced in the Further Education and Training (FET) phase (grade 10-12) that deals with different lines for the purpose of communicating graphically. This subject is abstract in nature (Khoza, 2013; Mlambo, Maeko & Khoza, 2023) which makes it unique from other subjects offered in schools which are theoretically based.

Civil Technology is another subject also introduced in the FET phase along Electrical Technology and Mechanical Technology which are designed to equip learners with hands on skills for the purpose of enrolling for apprenticeship and get trade test certificates from organisations or enabling pupils to become entrepreneurs (Mtshali & Singh-Pillay, 2023a, 2023b). These subjects are mostly based on equipping learners with hands-on skills to prepare them for life after school and they have been deemed as the gateway for the engineering courses (Mlambo et al., 2023; Sotsaka, 2015, 2019) because of the significance they hold towards preparing learners for the engineering world.

Maeko (2024) asserts that the primary aim of technical stream in schools is to improve the quality of life since it helps individuals to become economically active. In addition, Hove (2022) sees technical subjects as practical in nature that focus on concepts and principles in the built environment. This subject consists of construction, civil services and woodworking (Mtshali & Msimango, 2023). While mechanical technology is divided into welding and metal work, automative and fitting and machining. On the other hand, Electrical technology consists of electrical, electronics and digital systems.

Literature suggest that technology education is meant to impart technical skills to pre-service teachers so that they can be able to venture into industries where they will be employed to use such skills and contribute to skills development through economic growth (Maeko, 2024). This shows the significant role that is played by EGD in equipping learners with foundational skills so that they thrive in the technical stream. Despite EGD's role in technical stream, little research has explored its specific impact on technical subjects' performance in South African universities. For instance, Singh-Pillay and Sotsaka (2021) argue that EGD is a gateway subject to engineering courses. This study only explored the significance of EGD in relation to educational engineering courses but there is a paucity of studies that places EGD at the centre of technical stream. As a result, this study was aimed at investigating the centrality of Engineering Graphics and Design in studying technical subjects. This enquiry was necessitated by the growing number of teacher training universities who no longer consider EGD as a mandatory selection for pre-service teachers trained to be technical subjects' teachers. The above is contrary to the Department of Basic Education stance, where EGD is a compulsory subject to all learners in technical stream (Department of Basic Education, 2011).

This enquiry was guided by the following main research question: What is the centrality of Engineering Graphics and Design in studying technical subjects?

The above main research question is supported by the following sub research questions:

RQ1: How do pre-service teachers studying Civil Technology with EGD perform compared to those studying Civil Technology without EGD?

RQ2: What are the lectures' views about Engineering Graphics and Design in studying technical subjects?

2. Literature Review

2.1. Theoretical Benefits of Engineering Graphics and Design

The significance of drawing is articulated in the findings of a study by Abd-Malek, Jaidin, Shahrill and Jawawi (2024) which indicated a positive impact of using drawing as a teaching and learning strategy for a digestive system learning in science. Abd-Malek et al. (2024: page 168), further assert that "drawing and Science are always taught together because an illustration is needed for the learners to translate what they have observed". Technical subjects are regarded as the gateway subjects to the engineering field which requires a high level of creativity and if most pre-service teachers are neglecting drawing it could result in dire consequences on the future of engineers that will be produced in South Africa (SA).

Similarly, participants in Schenk's (2014) study were concerned that creativity could be impaired if drawing is neglected in schools and universities, emphasising the difference between 'repurposing' secondary sources. Based on the above, it is apparent that drawing (EGD) plays an important role in many subjects. However as mentioned above there is a paucity of studies have been conducted that exposes the importance of EGD in its curriculum. For that reason, the above articulations have necessitated the need to investigate the centrality of Engineering Graphics and Design in studying technical subjects.

2.2. Role of Visual-Spatial Skills

Singh-Pillay and Sotsaka (2021) indicate how EGD develops spatial and visualization skills. They further argue that this module helps pre-service teachers develop spatial reasoning, in turn enabling them to visualize objects in two dimensional (orthographic) and translate them into three-dimensional (isometric) representations and vice versa. As such, this is of paramount importance in technical subjects, where the ability to understand the spatial relationships of components is fundamental to problem-solving and designing.

Denson, Jones and Williams (2022) argue that EGD acts as a bridge between theoretical knowledge and practical application. By learning to create detailed technical drawings, pre-service teachers gain an in-depth understanding of the theoretical principles underlying engineering designs. As such, Martín-Erro and Menéndez-Pidal (2024) assert that "this integration of theory and practice is particularly significant in technical subjects that require precision and accuracy". This spatial visualization skill is not only essential in EGD but in other technical subjects, but it can be best learnt through engaging with EGD. Which further stamps the importance of EGD in studying technical subjects.

2.3. Engineering Graphics and Design Technical Disciplines

2.3.1. Mechanical Technology

Engineering Graphics and Design serves as an essential component in technical stream. The module provides the foundational skills and knowledge which are required for problem-solving, visualization, and effective communication in engineering and related world. The importance of EGD in technical subjects (Mechanical technology, Civil Technology and Electrical technology) is multifaceted, as such, the module contributes to the development of practical and theoretical skills which are necessary for both academic success and work application.

Within the engineering world, despite several languages used, graphical communication serves as a universal language to communicate ideas and designs. Giesecke, Lockhart, Goodman and Johnson (2023) posit that "graphical representation is a basic, neutral form of communication that is not tied to a particular time or place". Engineering Graphics and Design enable individuals to interconnect ideas, understand designs, and concepts effectively through standardized graphical representations in a manner of technical drawings, schematics, and blueprints. Denson et al. (2022) argue that graphical communication is particularly crucial in technical subjects, where accurate and explicit communication is essential to convey multifaceted concepts.

Considering the following as an example, within mechanical technology in relation to the curriculum, there's a part where technical learners do a Practical Assessment Task, commonly known as PAT, this is where pre-service teachers are required to produce a certain project. To do so effectively, the project emanates from a design (graphical presentation) with measurements and different views, learners must read through it and come up with the final project or prototype. Thus, EGD assists in enhancing technical communication. Figure 1 shows an overall graphical representation of a rocket stove to be designed by mechanical technology pre-service teachers. As it is visible that different parts are marked, they would appear separately to show the different dimensions, with instructions on how material should be cut and joined, this requires an understanding of graphical communication.

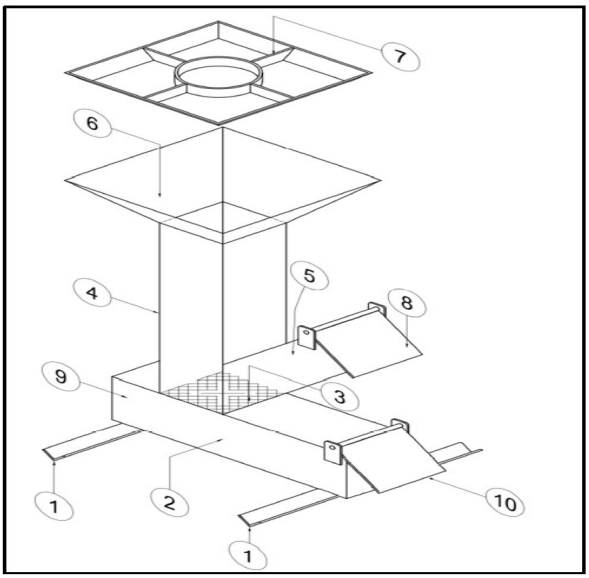

Figure 1. Graphical representation of a rocket stove (PAT document, Mechanical Technology, 2025)

2.3.2. Civil Technology

The design process in engineering relies heavily on understanding graphical communication. Within Civil engineering, when a building is to be constructed, there is normally a blueprint which is sought from the architectural designer, where the builders need to have a visual representation of what the final building should look like. The blueprint gives information such as how deep the foundation should be, dimensions of the walls and how they can be reinforced, just to mention a few. Figure 2 below shows a simple foundation, columns, and ground floor beam layout, with some data already alluded to above. As a result, in order to understand such data, it will be almost impossible without the knowledge of graphical communication. Giesecke et al. (2023) put forth that EGD "provides the tools for conceptualizing and developing ideas, which can then be tested, refined, and realized".

Moreover, Cavone, Bozza, Carli and Dotoli (2022: page 1587) articulate that "technical drawing is used in automotive engineering, construction, and manufacturing to model, simulate, and optimize designs before production, this is an imperative exercise as it assists in reducing errors and improving efficiency, consequently allowing industries to be cost effective". Additionally, Cavone et al. (2022) further argues that modern industries increasingly rely on advanced computer-aided design (CAD) tools. Consequently, EGD forms the foundation for learning these tools, equipping pre-service teachers with the skills to use software like AutoCAD and SolidWorks.

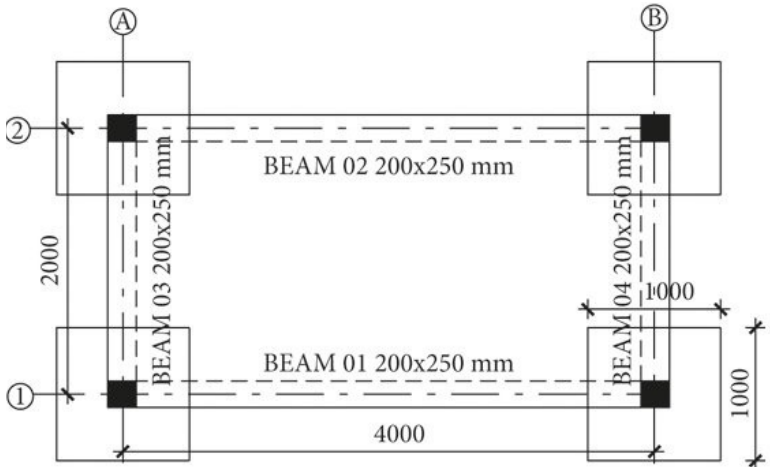

Figure 2. Simple foundation, columns, and ground floor beam layout (Kigoye & Kyakula, 2022)

2.3.3. Electrical Technology

In technical subjects, this technological competency is critical for staying competitive in the workforce. When it comes to the electrical trade, EGD is crucial as the electrical sketch provides pre-service teachers with knowledge on the incoming lines including their voltages, capacity, size, and rating. Additionally, the sketch shows the location of electrical components such as distribution boxes, switches, plugs, winding connections and other electrical components to be installed. Figure 3 below shows a simple floor plan, with all the electrical components to be installed. Looking at the figure, the way the data is provided, needs the installer to have an idea of EGD, as they need to know the specific rooms where the components need to be mounted.

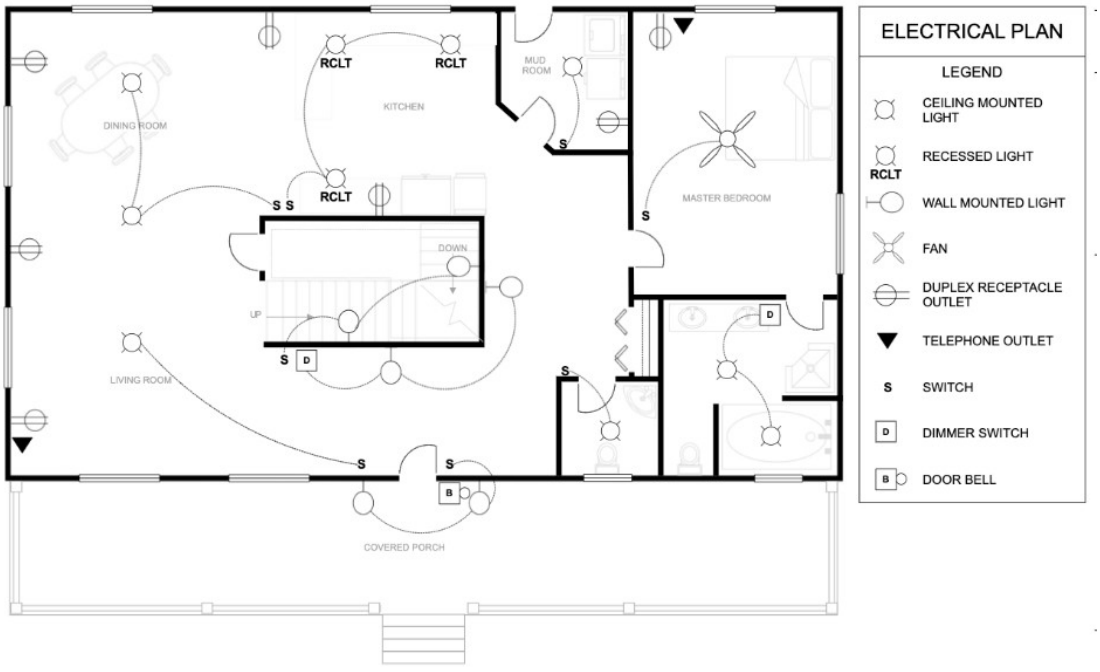

Figure 3. Electrical floor plan (Rashid, Algeelani, Al-Gailani, & Sariff, 2021)

To understand EGD, Xu, Zhu and Gao (2024: page 138) explains it as a "technical drawing used to define the requirements for engineering products and components". Reading and understanding drawings, is an exercise that involves a highly developed ability to look at lines on the page and convert them from several pictures to form a three-dimensional shape. Ramatsetse, Daniyan, Mpofu and Makinde (2023: page 705)

allude that this "requires pre-service teachers to comprehend the basic principles of international standards well and understand the principal rule of drawing".

A study done by Singh-Pillay and Sotsaka (2020) focused on first-year Pre-service EGD teachers. This was due to the fact that "studies on the spatial-visual abilities of Pre-service Engineering Graphics and Design teachers are absent in mainstream spatial-visual literature" (Ramatsetse et al., 2023). Findings from the above study indicated a substantial improvement in how pre-service teachers understand assembly drawing. This shows that engaging with EGD does improve understanding of certain concepts hence this study is aimed at investigating the significance of EGD in studying technical subjects such as Electrical Technology.

2.4. Industry Application of Engineering Graphics and Design

When it comes to technical subjects, precision is essential therefore makes EGD pivotal as it instils a meticulous approach to detail, ensuring that pre-service teachers produce drawings and designs that meet industry standards. Cavone et al. (2022) make us aware that the module instils focus on accuracy and minimize errors in manufacturing, construction, and other technical processes. Within the engineering field, collaboration among professionals from different disciplines is common.

EGD provides a common platform for understanding and interpreting technical information, making it easier for engineers, architects, and technicians to work together effectively (Martín Erro & Menéndez-Pidal, 2024). The last point this study wishes to make is that EGD equips pre-service teachers with skills that are highly valued in the job market, including technical drawing, AutoCAD proficiency, and an understanding of industry standards. This makes pre-service teachers better prepared for careers within engineering, design, and other technical related fields.

The significance of EGD in technical subjects cannot be overstated. It is a cornerstone of technical stream, providing pre-service teachers with the tools to visualize, design, and communicate effectively. As industries continue to evolve, the role of EGD in equipping pre-service teachers with the necessary skills for modern engineering and technical profession has become increasingly important. This therefore compels universities to prioritize the pairing of EGD and other technical subjects to ensure that pre-service teachers are well-prepared to meet the challenges of the 21st-century workforce.

3. Theoretical framework

3.1. Constructivist Learning Theory

This study revolves around the significance of EGD in studying other technical subjects like Mechanical, Civil and Electrical Technology. It is known that EGD is a subject that is practical in nature where pre-service teachers engage in drawing. In other words, EGD is seen as the communication through graphical representation of anything before it can be done physically which makes it a cornerstone of the engineering field. Based on the above, it is for that reason that this study adopted the constructivist learning theory as the theory that underpinned this study. This framework draws from the works of Vygotsky (1978) which argues that in constructivism setting pre-service teachers construct knowledge themselves. This framework also feeds from the Self-Directed Learning theory that allows pre-service teachers to engage independently with practical tasks, improving their autonomy and self-reliance. It further aligns with the abstract nature of EGD, enabling pre-service teachers to develop crucial problem-solving skills and the development of the spatial visualisation skill.

The nature of technical subjects allows learners to engage with the content themselves which aligns well with the practical nature of EGD, emphasizing student autonomy and self-reliance in the learning process. This framework aligns with this study in many ways (1) Civil Technology provides pre-service teachers with the opportunity to engage in practical content such as bricklaying, which first requires accurate technical drawings skills that are developed through the study of EGD (2) the same can be said with mechanical technology as learners engage with motor/machine parts of a car, such skills are learnt directly

from EGD in mechanical assembly section. The above underscores the significant role EGD plays in studying technical subjects which is the gap that this study aims to fill.

Wibowo, Wangid and Firdaus (2025), assert that constructivist learning theory believes that pre-service teachers actively construct knowledge through experiences. In this study, experiences refer to the ongoing drawing tasks in EGD that help pre-service teachers develop essential drawing skills relevant to the engineering field. Constructivist principles highlight the value of active learning, where pre-service teachers form meaningful connections between EGD and broader technical subjects such as Mechanical, Civil, and Electrical Engineering.

This suggests that pre-service teachers enrolled in technical subjects should include EGD in their subject selection, as it equips them with essential drawing skills that are critical for success in engineering-related fields. This subject is regarded as the first language of all designers de-Vere, Kapoor and Melles (2011), hence it is imperative that EGD is included throughout educational engineering courses. The above articulations align well with objectives of this study, and the constructivism theory was deemed relevant to underpin this study.

4. Design/methodology/approach

4.1. Research Paradigm

Literature shows that there are several paradigms that can be used in research depending on the stance a researcher comes from. Just to mention a few, these paradigms are positivism, constructivism and the pragmatism paradigm. This stance is seen as a worldview or a lens that a researcher uses to solve the phenomena under investigating (Kivunja & Kuyini, 2017).

Kaushik and Walsh (2019) further maintain that it is the perspective that informs the interpretation of findings. This study followed a mixed-methods stance therefore a pragmatic paradigm was best suited (Allemang, Sitter & Dimitropoulos, 2022; Kaushik & Walsh, 2019). This paradigm was formed to eradicate biases that comes with employing either positivism or constructivism paradigm in a mixed-methods studies (Alharahsheh & Pius, 2020).

4.2. Research Approach

This study adopted a mixed methods approach which relies heavily on both quantitative and qualitative data. These methods are lauded for the ability to balance the limitations of each approach resulting in a robust interpretation of findings. Originally, quantitative data provides a numerical data whereas qualitative data provide a depth insight to the phenomena being investigated. Combining both in one study compensate for each method bias (Dawadi, Shrestha & Giri, 2021). In this study, quantitative data was collected through examining test scores of 56 Civil Technology pre-service teachers, and the qualitative data was sought using open ended questionnaire from the technical lecturers to gauge their views about the centrality of EGD in studying technical subjects.

4.3. Research Design

This study adopted an explanatory sequential design. This approach first collects and analyses quantitative data and then follows up with qualitative data collection and analysis to enhance the strength and validity of the findings through complementary insights from both types of data.

The researcher used Civil Technology test scores from 56 pre-service teachers to gather how they perform with or without EGD. The findings that emerged were supported by the qualitative data from open-ended questionnaires to gather the lecturer's insight about the centrality of EGD. The findings gathered from the test scores was not conclusive enough to support the claim that EGD is central in studying technical stream their insights from the lecturers were the much-needed reinforcement.

4.4. Participants and Sampling

This study aimed to highlight the central role of EGD in the technical stream by involving five technical lecturers and 56 pre-service teachers enrolled in technical subjects. The sample of 56 pre-service teachers included both pre-service teachers studying EGD and those who are not. Their input provided insights into how pre-service teachers perform in topics that require drawing skills and gauge whether EGD is indeed central to studying technical subjects. Thereafter, purposive sampling was used to select five lecturers in the school of education who lecture technical modules.

It is notable that the technical department is a very small within this university hence only five lecturers were available for selection. Purposive sampling is a non-probability method in which researchers deliberately choose participants based on specific characteristics (Taherdoost, 2016). McCombes (2019), similarly notes that this approach involves the researcher applying their expertise to select a sample most relevant to the research objectives.

In this study, purposive sampling was used because the researcher was interested in lecturers who meet the criteria which was to be a technical subject lecturer within the school of education. Biographical information of the participants is displayed in Table 1.

Name	Gender	Major modules	Experience
Lecturer A	Male	Civil Technology, Engineering Graphics and Design	15 years
Lecturer B	Male	Mechanical Technology and Mathematics	6 years
Lecturer C	Male	Electrical Technology and Mathematics	9 years
Lecturer D	Male	Civil Technology, Engineering Graphics and Design, and Mathematics	6 years
Lecturer E	Male	Civil Technology and Mathematical Literacy	13 years

Table 1. Lecturers' biographical information

The table above indicates that participants specialize in a range of technical subjects, ensuring that the data generated from the semi-structured interviews will be unbiased. From the table it can also be depicted that only males are technical subjects' lecturers which further demonstrates that technical field is mainly dominated by males. It is worth noting that having only male participants may not accurately reflect the other gender's experiences and the findings may only be generalised on males. However, the substantial quantitative data was sought from both gender which limit the potential gender biases in the data collected.

4.5. Data Collection Instruments

Since this study adopted a mixed methods approach, qualitative data was collected though an open-ended questionnaire which was designed to get lecturers insight into the centrality of EGD in studying technical subjects. assert that open ended questionnaire gives participants an opportunity to respond without being restricted to a yes or no response (Hammer & Wildavsky, 2018). This method of data collection also enables participants to share their views and experiences openly, without being limited by a fixed word count or confined to simple yes or no responses, as is often the case with closed-ended questionnaires. Employing this method to collect data was deemed suitable because it captures the specificity of a particular situation and in this study the specificities about the centrality of EGD were uncovered from the lecturers.

On the other hand, test scores were also used as a source of quantitative data. This study analysed the test scores of 56 pre-service teachers in Civil Technology to determine whether studying EGD impacts their performance. The tests were on Graphics and Communication section, emphasizing technical drawing skills and the visual representation of construction-related designs and structures. These test scores were considered relevant as they required pre-service teachers to demonstrate their drawing abilities, aligning

closely with the core objectives of EGD. It is noteworthy that test scores from the 56 Civil Technology pre-service teachers were done and recorded prior to this study.

4.6. Data Analysis

Data generated from the tests scores were analysed using a Statistical Package for Social Sciences (SPSS) version 30. In the analysis, data was cleaned and coded on excel and exported to SPSS version 30 for descriptive analysis looking for mean, range and standard deviation. Data was also subjected to visual representation in the form of clustered bar graph to interpret relationships between pre-service teachers who did Civil Technology with and without EGD. To determine the significance of EGD to improve their performance a cross tabulation was also used to further show the centrality of EGD in studying technical subjects.

Data generated from the open-ended questionnaires was subjected to a thematic analysis. The themes were generated through following Braun and Clarke (2006), six steps of thematic analysis. After transcription, data was carefully taken through the six steps by Braun and Clarke (2006) as follows: familiarising yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. During the analysis of the findings this study conformed to the six (6) steps mentioned above.

4.7. Ethical Considerations

Ethics is another important component in research that cannot be overlooked as it deals with how participants such as humans and animals should be treated. It also looks at how the researcher should conduct the study within ethical guidelines. This study was conducted within the university of technology situated in uMgungundlovu district; hence ethical clearance was sought from the institutional research ethics committee which was assigned Ethical Clearance number IREC 005/25. After the clearance letter was sought informed consent letters was sent to the concerned lecturers and participants were informed of participation that is voluntary, and they can decide to withdraw anytime.

5. Results and Discussion

This study aimed to investigate the significance of EGD in studying technical subjects such as Civil Technology, Mechanical Technology and Electrical technology. This enquiry was underpinned by the following main research question: What is the centrality of Engineering Graphics and Design in studying technical subjects? As mentioned above, data were collected through open-ended questionnaires from five lecturers and test scores from 56 Civil Technology pre-service teachers. Presentation and discussion of quantitative results are presented below.

The data presented below was cleaned, coded on excel and exported to SPSS version 30 for descriptive analysis, graphical presentation and cross-tabulation to gauge the centrality of EGD in studying technical subjects as informed by the objectives of this study above.

5.1. Presentation of Data from Civil Technology II Pre-Service Teachers

The table below shows the descriptive data of the test taken by the Civil Technology II pre-service teachers.

Subject Choice	Count	Mean	Min	Max	Fail Count	Fail Rate (%)	Std Dev
EGD	10	51.00	0	75	3	30.0	22.21
Not EGD	16	29.69	0	60	14	87.5	18.30

Table 2. Descriptive statistics for Civil Technology II pre-service teachers

The table above shows that from a total of 26 pre-service teachers enrolled for Civil Technology II, only 38.46 % (N=10) took EGD and the majority (61.54%, N=16) did not take EGD. This shows the decline in pre-service teachers who are opting for EGD, which is the main issue that this study is trying to address. The table above depicts those pre-service teachers who opted for EGD who had a greater performance mean score of 51.00 compared to their counterpart of 29.69. It can also be deduced from the table above that EGD has a much lower fail rate (30%, N=3) compared to Not EGD (87.5%, N=14).

It is also evident that the minimum was 0 for both groups, however the maximum mark came from the group that did EGD. In simpler terms, EGD pre-service teachers had a broader performance range (0 to 75) compared to Not EGD pre-service teachers (0 to 60). Pre-service teachers who did EGD also recorded a higher std deviation of 22.21 compared to that of 18.30 indicating a wider spread of scores in EGD. Figure 4 below further shows the analysis involving Civil Technology II pre-service teachers.

Figure 4 provides a visual representation of the test scores for Civil Technology II pre-service teachers. It illustrates that most pre-service teachers who did not include EGD in their module selection performed poorly on the tests. Conversely, the minority of pre-service teachers who opted for EGD mostly achieved good test results. This highlights the centrality of EGD in the study of technical subjects. To further clarify the results depicted in Figure 4, a contingency table (Table 3) is presented below.

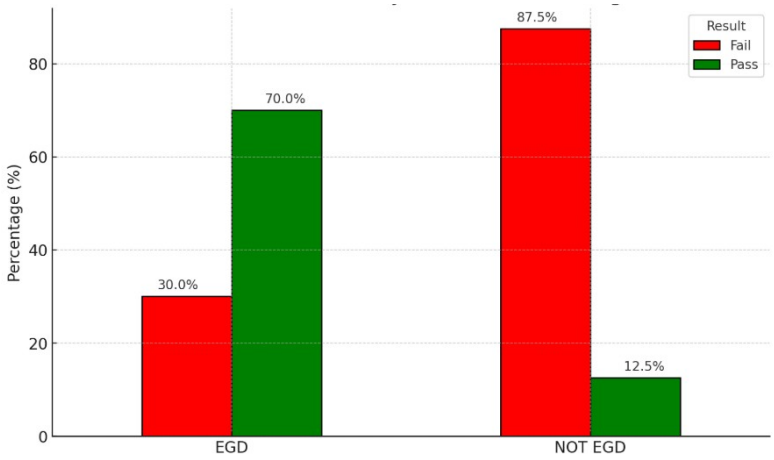

Figure 4. Civil Technology II pre-service teachers result

Subject Choice	Fail (N)	Fail (%)	Pass (N)	Pass (%)	Total (N)	Total (%)
Not EGD	14	82.4	2	22.2	16	61.5
EGD	3	17.6	7	77.8	10	38.5
Total	17	100	9	100	26	100

Table 3. Cross tabulation for Civil Technology II pre-service teachers

The cross-tabulation above reveals that out of the 26 pre-service teachers enrolled in Civil Technology II, the majority (61.5%, N=16) did not take EGD, while 38.5% (N=10) included EGD in their module selection. Among the 16 who did not take EGD, only 12.5% (N=2) passed the test, whereas the overwhelming majority (87.5%, N=14) failed. In contrast, of the 10 pre-service teachers who took EGD, a significant majority (70%, N=7) passed the test, while 30% (N=3) did not perform well.

5.2. Presentation of Data from Civil Technology III Pre-Service Teachers

This study analyzed test scores from the pre-service teachers doing Civil Technology. Above analysis for Civil Technology II was done, in this section an analysis for Civil Technology III pre-service teachers will be done. Table 4 below shows descriptive data for Civil Technology III pre-service teachers.

Subject Choice	Count	Mean	Min	Max	Fail Count	Fail Rate (%)	Std Dev
EGD	4	76.75	71	81	0	0.0	4.35
Not EGD	26	50.92	23	75	11	42.3	10.73

Table 4. Descriptive statistics for Civil Technology III pre-service teachers

As can be deduced from the table above, from a total of 30 scripts analyzed only 13,33% (N=4) were EGD and a staggering 86.67% (N=26) did not do EGD. This means that more pre-service teachers are opting against taking EGD which is a similar trend that was observed in Civil Technology II pre-service teachers above. A higher mean score of 76.75 was recorded from the pre-service teachers that did EGD and a lower mean score of 50.92 for the pre-service teachers who did not do EGD. This further shows that pre-service teachers doing EGD are more likely to perform better compared to their counterparts.

Table 3 above further shows that pre-service teachers who did EGD achieved a 100% pass rate and those without EGD recorded a fail rate of 42.3% (N=11). This great performance by EGD pre-service teachers is further supported by the scores that range from 71 to 81 for the EGD pre-service teachers and 23 to 75 for those who opted against EGD. Further analysis is displayed below by means of clustered bar graph (Figure 5) and the crosstabulation table (Table 4) to show the relationship between doing EGD and not doing EGD.

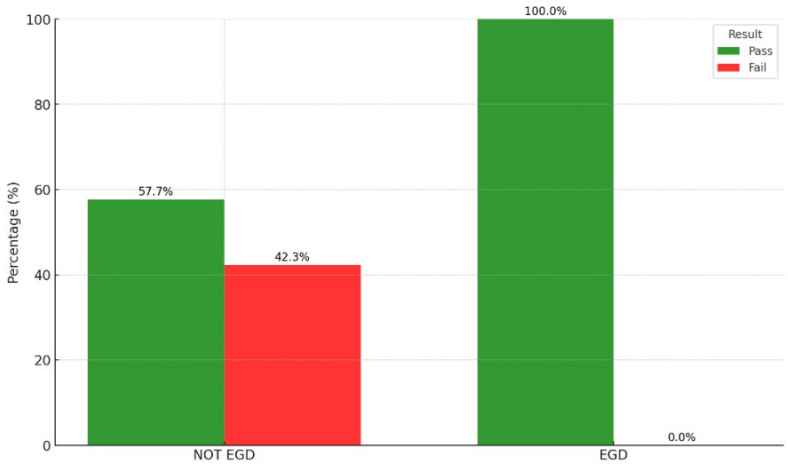

Figure 5. Civil Technology III pre-service teachers result

Figure 5 provides a graphical representation of the test scores obtained by Civil Technology III pre-service teachers. The clustered bar graph highlights that most pre-service teachers chose not to take EGD. However, among the minority who opted for EGD, all pre-service teachers successfully passed the test, with the highest score recorded in this group. Similar to the observations from Civil Technology II, taking EGD positively influences performance in chapters requiring drawing skills, such as graphical communication. This underscores the central role of EGD in studying technical subjects. To further contextualize these findings, the contingency table below (Table 5) provides additional clarity.

Subject Choice	Fail (N)	Fail (%)	Pass (N)	Pass (%)	Total (N)	Total (%)
Not EGD	11	100	15	78.9	26	86.7
EGD	0	0	4	21.1	4	13.3
Total	11	100	19	100	30	100

Table 5. Cross tabulation for Civil Technology III pre-service teachers

The findings from Table 5 indicate that out of 30 pre-service teachers enrolled in Civil Technology III, the majority (86.7%, N=26) did not take EGD, while a small proportion (13.3%, N=4) opted for EGD. Among those who did not take EGD, 42.3% (N=11) failed the test, while 57.7% (N=15) passed. In contrast, all pre-service teachers who took EGD achieved a 100% pass rate. These results further highlight the significance of EGD in studying technical subjects, as it enhances pre-service teachers ' performance in chapters requiring drawing skills. To further bring more clarity to the data presented in tables above, effect size and confidence intervals are discussed in the table below.

Group	EGD Mean	Non-EGD Mean	Mean Difference	Cohen's d	95% CI (Mean Difference)
Level III	76.75	50.92	25.83	2.52	19.63-32.03
Level II	51.00	29.69	21.31	1.07	4.01-38.61

Table 6. Effect sizes and confidence intervals

The findings above show that pre-service teachers who opted for EGD consistently outperformed their counterparts in both levels of study. In level III group the mean score for those with EGD (M = 76.75) which is significantly higher than those without EGD (M = 50.92) resulting in a very large effect size (Cohen's d = 2.52) and the mean difference 19.63 – 32.03. Similarly, in level II the EGD group (M = 51.00) outperformed the non-EGD group (M = 29.69), with a large effect size (Cohen's d = 1.07). However, the 95% confidence interval for the mean difference was wider, ranging from 4.01 to 38.61, indicating greater variability and less precision in this estimate.

5.3. Discussion of Data from the Civil Technology Pre-Service Teachers

The findings presented above from the tests score taken by the Civil Technology II pre-service teachers shows that there is a small portion of pre-service teachers who are taking EGD to third level of study this is evident from the data above that from 26 pre-service teachers who enrolled for Civil Technology II majority of them (61.5%, N=16) did not take EGD and only a minority of 38.5% (N=10) took EGD.

The same trend was observed from the Civil Technology III pre-service teachers as from the group of 30 pre-service teachers enrolled for Civil Technology III only (13.3%, N=4) took EGD and the majority (86.7%, N=26) opted against EGD. This signals that most pre-service teachers are opting against taking EGD as shown in the literature that most teacher training universities are opting against making EGD a compulsory selection for pre-service teachers enrolled in technical stream.

The majority of pre-service teachers opting against drawing is also evident abroad as it has been reported that in the UK, drawing skills are gradually declining citing the phasing out of drawing modules in favour of new content (Fava, 2020). This is owing to the number of pre-service teachers who are opting against choosing EGD which is against the status core which maintains that EGD should be a mandatory selection (Maeko & Khoza, 2017).

The above assertion is backed by the descriptive findings above which showed that pre-service teachers who took EGD in Civil Technology II group performed well in the tests with an average of 51.00 compared to 29.69 of those pre-service teachers who did not do EGD. The same was observed in the pre-service teachers enrolled for Civil Technology III as those with EGD recorded a mean score of 76.75 where else those who opted against EGD recorded a mean score of 50.92. The effect sizes and confidence intervals data above suggest that exposure to EGD is associated with substantially stronger performance among pre-service teachers.

From the findings above it is evident that most pre-service teachers are opting against choosing EGD, these findings support the claim made by Khoza (2013) that pre-service teachers opt to not choose EGD because of being an abstract subject that most pre-service teachers struggle with. However, Maeko and Khoza (2017) argue that this is against the status quo in technical stream which maintains that EGD

should be a compulsory major subject to the university pre-service teachers who take Mechanical, Electrical and or Information Technologies.

The same notion is echoed by Department of Basic Education (2011), that EGD should be a compulsory major in learners engaging in technical stream. This basically means that EGD is significant and that is backed by the findings above which showed that pre-service teachers who took EGD performed better in the tests as compared to their counterparts. The importance of drawing is further articulated in the literature by Abd-Malek et al. (2024), that drawing is very significant in studying the Science, Technology, Engineering and Mathematics (STEM) subjects and therefore it should be a mandatory selection among pre-service teachers enrolled in STEM courses.

5.4. Presentation of Data from Open-Ended Questionnaires with the Lecturers

Data collected from the lecturers was meant to respond to RQ2: What are the lecturers' views about Engineering Graphics and Design in studying technical subjects? Resulting data were analyzed thematically and from the analyses on five themes emerged.

The themes were generated through following Braun and Clarke (2006), six steps of thematic analysis as mentioned in the methodology section above. After transcription, data was carefully taken through the six steps which resulted in the themes presented below.

5.4.1. Theme 1: The Importance of Engineering Graphics and Design in Technical Careers

Lecturers were asked: What is the significance of EGD in preparing pre-service teachers for careers in technical fields? Below is how they responded:

Lecturer B said the following:

> *"It assists them in having the common understanding of engineering information like a building plan. I remember this other time I hired a guy to build a house, who was not good articulating the common knowledge. He kept on referring to the house plan to get it right, I think that was a way of understanding how the building should be through the graphical representation of it".*

Lecturer C maintained what was said by lecturer B above:

> *"EGD is the umbrella of technical careers that lays a foundation for the deeper content of technical stream. While it focuses more on graphical communication, it paves the way for in-depth knowledge, which is covered in specialised technical fields such as Civil, Electrical and Mechanical fields".*

Similar views were articulated by Lecturer D emphasizing the importance of EGD:

> *"Most of the things being done in Engineering field they require drawing for example a house cannot be built without a floor plan; a car cannot be made without sketched first so basically everything requires to be drawn first before it can be manufactured hence drawing is very significant for careers in technical fields".*

5.4.2. Theme 2: Engineering Graphics and Design as the Core of Technical Understanding

Lecturers were further asked the following question: How does EGD contribute to the understanding and application of technical concepts in your module? Below is how they responded:

Based on the above question Lecturer D had the following to say:

> *"In Civil Technology, pre-service teachers are expected to draw floor plans with electrical components and other features and for them to be able to do that they require the basic skills of drawing acquired in EGD. In a nutshell, EGD is the heart of technical subjects".*

Similar views were shared by Lecturer E:

"It provides the guidance for student/lecturer and promote accuracy when practicing practical activities. Also, it gives a clarity since it builds a real-life image in the mind of the student through graphics".

5.4.3. Theme 3: Engineering Graphics and Design Relevant in All Technical Subjects

To gauge the centrality of EGD, lecturers were asked the following question: Which topics in your module involve EGD and how? Below is how the lecturers responded:

In response to the above question the following remarks were made by Lecturer B:

"In Welding and Metalwork, it's on roof trusses. To make and weld them you need to understand the measurements which emanate from a drawing".

Lecturer D echoed his sentiment about the relevance of EGD in Civil technology:

"Topics in Civil Technology that involve EGD, is the Graphical Communication where pre-service teachers are expected to draw the floor plans and insert features. Theu further draw the elevations. Another section is where they are expected to draw vectors, bending and shear force diagrams".

Lecturer D views above were shared by Lecturer E:

"Graphics as means of communication skills through EGD (Civil Drawing) and applied mechanics".

5.4.4. Theme 4: Technical Curriculum Not Adequately Structured

The above theme emerged through lecturers asked the following: Do you think the current curriculum in the university adequately supports the goals of technical stream? Why or why not. And below is how they responded:

In response to the above, Lecturer B asserted:

"No, I feel it should be compulsory for pre-service teachers who do Mechanical Technology to do EGD or at least have it from high school because I have to teach the basics of EGD first before they understand the task/practical".

Lecturer B's concerns were further voiced by Lecturer C:

"In my alma mater university, EGD was done by everyone in the first year, but since it was made an option, it defeats the whole goal because pre-service teachers opt out of EGD and that will catch up with them when they are employed".

Technical curriculum not structured well was further echoed by Lecturer C:

"No, it does not because in the first year of study all pre-service teachers enrolled in technical stream should have EGD as a mandatory selection so that they can grasp the basic skills needed in technical field".

In the same vein as other lecturers, Lecturer D said the following:

"No, it does not, EGD forms a significant part of the technology education curriculum therefore all pre-service teachers enrolled in it should take EGD"

5.4.5. Theme 5: Engineering Graphics and Design as a Core Requirement in Technical Stream

Last question lecturers were asked is: How do you think technical modules could be structured in the institution to improve the relevance of EGD? Below are their responses.

When asked the above question Lecturer B had the following to say:

"Pre-service teachers doing Mechanical and Civil Technology must choose EGD as their core module".

EGD being a core requirement in technical was also mentioned by Lecturer C who said:

"Technical modules need EGD to be compulsory at first year, at least one semester so to get the basics of drawing".

Same assertions were echoed by Lecturer D:

"By making EGD the mandatory selection in the first-year study of pre-service teachers enrolled in technical stream".

Based on the above question Lecturer E maintained that:

"All technology education subjects must be aligned with EGD by ensuring that all the pre-service teachers have enrolled for the EGD module hence all tech subjects have a topic related to EGD".

5.5. Discussion of Data from Open Ended Questionnaires

The findings above indicate that lecturers view EGD as core aspects in studying technical subjects such as Civil, Mechanical and Electrical technology. From their responses they indicated that EGD lays a strong foundation for pre-service teachers to succeed in engineering fields. This is supported by Singh-Pillay and Sotsaka (2020) and Mlambo (2024) who view EGD as a gateway subject for engineering courses which offers a much-needed foundational knowledge about the field of engineering.

The findings underscore the need for EGD to be embedded in the technical stream curriculum as the mandatory selection up to the final year. This further invites all educational institutions who offer technical streams to reconsider making EGD a mandatory subject to pre-service teachers trained to teach technical subjects. This is supported by the lecturers who are the agents on the grounds that EGD should be a mandatory selection for all the pre-service teachers enrolled in technical stream as there are sections embedded in technical subjects that require drawing skills that are only taught in EGD. The lecturers' insights underline the significance of EGD in studying technical subjects hence they call for it to be a mandatory selection in technical stream.

The same is echoed by Ramatsetse et al. (2023), that EGD offers critical to support creation of product design in various fields such as architecture, mechanical, electrical, civil. It is further argued that EGD acts as a bridge between theoretical knowledge and practical application (Denson et al., 2022). The above articulations show that EGD is indeed essential for engineering courses such as automotive engineering, construction, and manufacturing to model, simulate, and optimize designs before production, this is an imperative exercise as it assists in reducing errors and improving efficiency (Cavone et al., 2022).

The views expressed by the lecturers are in line with the sentiment shared by Maeko and Khoza (2017), that status quo in technical stream maintains that EGD should be a compulsory major subject to university pre-service teachers who take Mechanical, Electrical, or Civil technology. The same notion is echoed by Department of Basic Education (2011), that EGD should be a compulsory subject in learners engaging in technical stream. Based on the lecturers' insights above, it is evident that EGD is central to studying technical subjects.

6. Conclusion

The findings that emerged from this study contribute to literature by exposing that EGD is not just a gateway subject for engineering fields as argued by Singh-Pillay and Sotsaka (2021) but pushes beyond that by exposing that EGD is central to providing background knowledge for all learners in the technical stream. The findings further revealed that pre-service teachers who took Civil Technology along EGD outperformed their counterparts in both groups.

Insights gathered through open-ended questionnaires clearly demonstrate EGD's significance. Lecturers emphasized that EGD serves as the foundation for technical subjects, especially those requiring drawing skills, such as creating floor plans with electrical components. They highlighted that EGD equips pre-service teachers with essential drawing skills, making it the backbone of technical stream. The

integration of AutoCAD in engineering courses reinforces EGD's critical role, as it lays the groundwork for advanced technical drawing.

The findings from the analysis of test scores further affirmed the pivotal role of EGD in technical subjects. Analysis of test scores revealed that pre-service teachers who had chosen EGD consistently outperformed those who opted against EGD. This outcome underscores the importance of EGD in technical studies. For example, among 30 Civil Technology III pre-service teachers, 42.3% (N=11) who had not taken EGD failed the test, while 57.7% (N=15) passed.

Similarly, in the Civil Technology II group, 61.5% (N=16) had not taken EGD, while 38.5% (N=10) included it in their module selection. Of those who had not taken EGD, a mere 12.5% (N=2) passed, whereas a substantial 87.5% (N=14) failed. Conversely, 70% (N=7) of the 10 pre-service teachers who took EGD passed the test, while only 30% (N=3) did not perform well. These results clearly indicate that EGD provides essential foundational drawing knowledge, aiding pre-service teachers in excelling within technical subjects. Overall, the alignment between pre-service teachers' test results and lecturers' perspectives underscores that EGD is indispensable in the study of technical subjects, fostering success both in academic settings and beyond.

7. Limitations of the study and Future Research

This study was confined to a single university of technology, with data collected exclusively from Civil Technology pre-service teachers to ensure its manageability. As a result, the findings cannot be generalized to all universities across South Africa but apply specifically to this institution. This limitation highlights the need for future research in other universities of technology, incorporating data from pre-service teachers in Mechanical and Electrical Technology to provide a more comprehensive and unbiased perspective.

The data from open ended questionnaires was sought only from male lecturers which may not accurately reflect the other gender experiences, and the findings may only be generalized on males not across everyone. This therefore paves a way for future studies to get such data on other institutions that train technical subject teachers and ensure that lecturers are of diverse nature with regards to gender and race to limit bias and generalisability of findings.

From the descriptive data presented above it revealed that only (N=14, 25%) of 56 pre-service teachers took EGD which is a very low intake given the significance of this subject. This, suggest for future studies to be conducted on factors influencing the low intake of EGD among technical pre-service teachers.

8. Recommendations

This study recommends that EGD should be a mandatory selection in the first-year study of pre-service teachers enrolled in technical stream. This will ensure that pre-service teachers grasp the much-needed foundational knowledge required to succeed in technical stream. The study further recommends that curriculum developers within the school / university administration to make EGD a mandatory selection in the technical stream.

The findings of this study further paved the way for interventions such as EGD bridging courses that pre-service teachers who come from schools without EGD background can be admitted to such intervention programs. This will assist pre-service teachers to gather the much-needed information to succeed in technical stream. This was influenced by many factors such as the common view that EGD is very challenging and some pre-service teachers come from schools without EGD background which makes it difficult for them to do EGD.

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