MODESTUM
EURASIA Journal of Mathematics, Science and Technology Education, 2025, 21(4), em2617
ISSN:1305-8223 (online)
OPEN ACCESS
Research Paper
https://doi.org/10.29333/ejmste/16172

Exploring synergies in Euclidean geometry and isometric drawing: A snapshot on grade 12 mathematics and engineering graphics & design

Philani Brian Mlambo [1*], Douglas Thembinkosi Sibusiso Sotsaka [1]

[1] Faculty of Arts and Design, School of Education, Durban University of Technology, Pietermaritzburg, SOUTH AFRICA

Received 08 January 2025 ▪ Accepted 12 February 2025

Abstract

Euclidean geometry and isometric drawing (ID) are significant topics in mathematics and engineering graphics & design (EGD), respectively. Over the years, these topics have developed a stigma due to learners' consistently poor performing when tackling these topics. Many scholars attribute this challenge to a lack of spatial visualization skill, which is crucial in understanding these key areas in mathematics and EGD. This paper adopts a mixed-methods approach underpinned by the pragmatic paradigm to explore potential synergies between Euclidean geometry and ID by examining teaching practices and learner performance in these topics. To achieve these objectives, the study employed convenience sampling to select 15 teachers from four schools in the uMgungundlovu District. Data collection methods included semi-structured interviews and document analysis, incorporating test results. Data from the interviews were thematically analyzed, while test data were processed using the statistical package for social sciences (SPSS). The findings revealed that while these topics are challenging for learners, there are notable similarities in how teachers approach their instruction. However, there was no conclusive evidence of synergy in learners' performance as the analysis of the scatter plot and statistical metrics revealed a weak negative correlation (r = -0.35) between the scores, indicating that higher performance in one subject does not necessarily align with higher performance in the other. Based on these findings, the study recommends fostering interdisciplinary collaboration between mathematics and EGD teachers through training programs and workshops. Such initiatives could enhance teachers' understanding of the potential connections between Euclidean geometry and ID, ultimately benefiting learners.

Keywords: synergies, isometric drawing, Euclidean geometry, mathematics, engineering graphics and design, spatial visualization

INTRODUCTION

Over the years concerns over learners' poor performance in topics such Euclidean geometry and isometric drawing (ID) have been well documented in the literature. Such spotlight is due to mathematics being regarded as a crucial subject across the globe Mosia et al. (2023), which is regarded as a fundamental subject which every learner is expected to pass in order to gain entry to one of the fundamental career fields such as engineering, medicine and finance. Engineering graphics and design (EGD) is also a crucial subject which provide leaners with a much needed foundation for the engineering careers (Mlambo, 2024). However, the importance of these subjects is not reflected in learners' performance. This is mainly because there has been an outcry from all spheres of the world due to high failure rates in mathematics specifically the Euclidean geometry section. This is collaborate by Machisi (2021) that teaching Euclidean geometry in South Africa (SA is a serious challenge which leads to most learners to undeform. In the same vein scholars such as (Mosia et al., 2023; Mudaly & Reddy, 2016), assert that learners perform better in other sections of mathematics but Euclidean geometry. This shows that learners are struggling in this section which contributes to a substantial percentage in the examination. Mthembu (2007) associates this poor performance in Euclidean geometry with learners who are doing mathematics out of will, it is also attributed to teachers lack subject

✉ PhilaniM7@dut.ac.za **(*Correspondence)** ✉ douglass@dut.ac.za

Contribution to the literature

- This study contributes to existing literature by highlighting the importance of spatial visualization skills in learners' understanding of Euclidean geometry and Isometric drawing, two critical areas in mathematics and Engineering Graphics & Design.
- It provides empirical evidence of a weak negative correlation between learners' performance in these subjects, challenging the assumption of direct synergies between them. The study also underscores the potential for interdisciplinary teaching approaches, suggesting that closer collaboration between mathematics and EGD teachers through professional development initiatives could enhance instructional practices and ultimately improve learner outcomes.
- By adopting a mixed-methods approach, the research enriches educational methodologies, offering valuable insights for policymakers, educators, and curriculum developers, particularly in contexts like the uMgungundlovu District in South Africa, where localized solutions are necessary to address teaching and learning challenges.

knowledge and pedagogical knowledge of teaching Euclidean geometry (Tachie, 2020).

A study by Mudaly and Reddy (2016) point the poor performance in Euclidean geometry to learners lack of visualization skill which assist in visualization of given diagrams. The assertion above is echoed in the national diagnostic report on learner performance in the 2022 matric mathematics paper 2, that teachers should focus on developing learners' visualization skills to analyze the question and the diagram for clues.

The lack of visualization skill in learners is also evident in learners doing EGD which contribute to learners' poor performance in ID. A grade 12 EGD diagnostic report further revealed that learners are failing ID of lack of spatial visualization skill. The lack of spatial visualization has also been observed in learners doing Euclidean geometry hence this study embarked on a journey to explore synergies Euclidean geometry and ID which can be used to improve the performance in these sections. This spatial visualization skill is a very important skill in EGD as it develops an ability to transform abstract concepts to concrete concepts (Khoza, 2013; Makgato, 2016; Makgato & Khoza, 2016; Sotsaka, 2015, 2019). This is an indication that spatial visualization skill plays a major role in learners who are doing mathematics and EGD as it aid them in understanding these sections better and has the potential to improve the performance of learners. The above is echoed by Abdullah and Zakaria (2013), who advance that geometry requires a visualization skill that is also used by learners in EGD. The above signals common practices in both areas and this has necessitated the need for this enquiry. As a result, the purpose of the study was to explore synergies in teaching and learning of Euclidean geometry and ID in mathematics and EGD in grade 12. And it was guided by this main research question:

1. What are the synergies between Euclidean geometry in mathematics and ID in EGD in grade 12?

The above main question was guided by the following sub research questions:

a. What teaching practices do mathematics and EGD teachers share when addressing Euclidean geometry and ID?

b. To what extent does learners' performance in Euclidean geometry influence their performance in ID, and vice versa?

c. What are the grade 12 learners' performance trends in Euclidean geometry (mathematics) and ID (EGD), and how do they compare?

LITERATURE REVIEW

History of Poor Performance in Euclidean Geometry

Poor performance in Euclidean geometry has been an ongoing issue across the globe. As a result, poor performance in Euclidean geometry led to many countries such as the United States of America (USA) omitting it from the schooling curriculum (Van Putten et al., 2010). Furthermore, Van Putten et al. (2010) argue that the USA was not the only country that omitted Euclidean geometry in its schooling curriculum as SA as well is one of the countries who omitted it. Machisi (2021) posits that in 2006 Euclidean geometry was removed from the schooling curriculum due to a series of poor performances. This is an indication that Euclidean geometry has always been a source of struggle in both teachers and learners across the world. However, the demands of the application of Euclidean skills in real life and the concern that if they are omitted meant teachers will not be able to teach Euclidean geometry ever again. The omission of Euclidean geometry from the curriculum resulted in lack of occurrence in the study of space and shape (Bowie 2009). The assertions compelled many countries to reintegrate Euclidean geometry into the schooling system. Consequently, in 2008 SA reintegrated Euclidean geometry on voluntary basis in the form of paper 3 (Van Putten et al., 2010).

The first matric class to try the paper on a voluntary basis resulted in 3.8% of learners attempting it and almost half of the learners got below 30% which is regarded as not achieving in SA. This was a back to square one in terms of results associated with Euclidean geometry. However, the stakeholders in education were not to be discouraged hence they remained resolute and hoped for better results in years to come. Consequently, in January 2012 SA reintroduced Euclidean geometry on a permanent basis under the then newly formed curriculum known as curriculum and assessment policy statement. Machisi (2021) advanced that the reintroduction of Euclidean geometry was applauded by many people including the institutions of higher learning who complained that preservice teachers who did not do geometry in school were weaker in teaching as compared to their counterparts. As much as this act brought a smile on the faces of many but it also sparked signs of fear. According to Govender (2014) and Ndlovu (2013), the fear from teachers were through not understanding why Euclidean was brought back as the previous problem led to it omission was still not sorted. Machisi (2021) points out that the fear from teachers were quickly addressed as the department of basic education (DBE) conducted workshops to equip teachers so that they can teach Euclidean geometry.

However, not all teachers were fully satisfied as 60% of the teachers who attended these workshops indicated that they were still not confident in teaching Euclidean geometry (Dube, 2016; Olivier, 2013, 2014). Dube (2016) further points that in some instances the facilitators of the workshops were also clueless. This has led up to the present moment where learners are still under performing in Euclidean geometry and it has been associated with poor teaching skills from teachers or lack of skills by learners to fully understand the concepts of Euclidean geometry. Consequently, this study sought to explore the synergy in teaching Euclidean geometry in mathematics and teaching of ID in EGD as in these sections learners are performing poorly. This is being done as a way of borrowing skills and strategies from one subject to another so that poor performance can be curbed.

Isometric Drawing

Drawing is a communication language that requires one to be able to understand and interpret different lines. Feasibly, an ability to imagine the appearance of an object before and after it is rotated in space. In spite of how many times one repeats the method or technique for constructing ID from the given two dimensional (2D) to three dimensional (3D), learners one way or another, they will have challenges. Learners would understand during the lesson demonstration in class. Giving them an individual task to do becomes problematic. They will have challenges to interpret a given drawing. This is an indication of low ability to interpret lines and visualize them appropriately.

ID is a 3D, which is drawn by using two receding axes inclined at 30 degrees angle (Upadhe et al., 2018). They further state that isometric also encompasses other lines which are referred to as non-isometric lines, that cannot be drawn as 30 degrees but rather require an auxiliary view. Isometric drawing is one way of converting from 2D to 3D which provides a detail visual presentation of what a real object should look like. Mendoza (2020) states that learners with less visualization ability find great difficulty in understanding the 2D concept that is needed to understand the object. Mendoza (2020) further mention that learning EGD requires learners to have a high level of spatial visualization skill so that they can be able to manipulate drawings or objects in their minds. The sections in EGD such as those that require learners to convert from 2D to 3D as well as those that require reverse transformation require learners to have visualization skills. Thus, the conversion of 2D to 3D and manipulation of objects will subject learners to a great cognitive demand more especially those with low spatial visualization skill (Samsudin et al., 2011).

Struggles Associated With Isometric Drawing

Engineering Graphics and Design is a technical subject that is done in the FET phase in high school. This subject relies heavily on converting from 2D drawing to 3D drawing or vice versa. There is a quite number of sections done in EGD which are ID, perspective drawing, assembly drawing (AD), and solid geometry among others. According to DBE (2011), ID and AD are sections that constitutes of more 60% of paper two which outlines the importance of these two sections in paper two of EGD examination paper. This basically means that learners can easily pass EGD paper with good marks if they are to perform very well in ID and AD. However, it is not the case as there has been an outcry from teachers that learners are performing poorly in ID. This statement is collaborated by 2021 EGD's diagnostic report which indicates that EGD pass rates dropped from the previous year's owing to poor performance in ID. The concerns with learners' poor performance are ID is outlined by Mlambo (2024) that learners are performing poorly in ID due to lack of a crucial spatial visualization skill.

Poor performance is further outlined by DBE (2022), that most learners drew the ID incorrectly as they demonstrated poor drawing skills. Similarly, DBE (2021) reported that most candidates are struggling to convert a 2D drawing to a 3D drawing of which is what ID is all about. A diagnostic report by DBE (2021), further revealed that the reason candidates are failing ID is because they lack a spatial visualization skill. Based on the above it is evident that there is a struggle in learners to pass ID and this poor performance can hinder learners from pursuing careers in certain areas such as architectural technology, civil engineering and draughtsman among other courses that require EGD. The poor performance in ID dates to when EGD was known as technical drawing (TD). The subject EGD has evolved from the subject previously known as TD

(Sotsaka, 2015). Even though EGD has been revamped from TD with a hope of improving things however some things remained unchanged like the poor performance in ID of which is still a problem in EGD till this present time.

Spatial Visualization in Euclidean Geometry and Isometric Drawing

The above sections have indicated that the poor performance in Euclidean geometry and ID is an issue that has been going on for a very long time. And measures have been put in place to try and curb the poor performance in these major areas with no luck, as grade 12 diagnostic report for both subjects always indicates that these sections are still giving learners problems. Studies done by (Olivier, 2013, 2014), indicated that teachers were subjected to workshops to assist them with skills to teach Euclidean geometry, but the poor performance has never been managed as learners are still struggling in these sections. To curb the poor performance in these sections many scholars have alluded to the fact that a spatial visualization skill is a very crucial skill that each learner should have to master these sections. In support of the above, Mudaly and Narriadoo (2023) assert that visualization technique is a powerful tool when working with the solving of problems in mathematics. The importance of visualization in mathematic is further echoed by Mudaly and Reddy (2016), who point that visualization in mathematics is something that has been around for over 2000 years and has been proven to assist in solving geometrical problems in mathematics. This shows how crucial visualization is in mathematics. The importance of visualization in mathematics is advanced by Sulistiowati et al. (2019) who asserted that most are lacking the visualization skill which is the level 1 skill according to van Hiele's thinking level.

Visualization is defined as the ability to see things in your mind that are not existing (Mudaly & Reddy, 2016). Mudaly and Reddy (2016) further posit that visualization in Euclidean geometry has to do with imagining diagrams physically or mentally. In simpler terms visualization is defined as having a skill to imagine diagrams that exist physically but can be manipulated mentally. Through acquiring this crucial skill, Euclidean geometry can be understood with relative ease. In a study titled "seeing the value of visualization" by Yin (2010) the roles/benefits of visualization are outlined which are:

(1) to understand the problem,

(2) to simplify the problem,

(3) to check connections, and

(4) to transform the problem from a complex form to a more understandable problems that can be best solved.

The latter role of spatial visualization is a synonym of how spatial visualization is defined in EGD, as Makgato and Khoza (2016) and Sotsaka (2015) see spatial visualization as a way of assisting learners move from abstract concepts to concrete concepts.

In EGD, spatial visualization has also been identified as a very crucial skill that can assist learners understand ID better. Khoza (2017) further mentioned that spatial visualization skill is very crucial not only in EGD but in science, technology, engineering and mathematics (STEM) programs. Lack of spatial visualization in certain individuals lead them to not succeed in technical fields (Khoza, 2017). Many scholars articulate that learners lack spatial visualization in EGD hinders them from understanding ID which in turn contribute to poor performance in ID. In support of the statement above, Khoza (2013), Makgato (2016), and Makgato and Khoza (2016) assert that learners have a low spatial visualization skill as they scored low in Purdue spatial visualization test they administered. This shows that learners with higher spatial visualization can perform better in Euclidean geometry and ID. Consequently, this study sought to explore the effects of spatial visualization in both sections and if passing either section translate to passing the other section.

RESEARCH METHODOLOGY

Research Paradigm

In research there are several paradigms that a researcher can employ being influenced by the perspective they are coming from. Kivunja and Kuyini (2017) assert that paradigm is a worldview of the researcher's worldview. Kaushik and Walsh (2019) further maintain that worldview is the perspective or set of shared beliefs, that informs the meaning or interpretation of research data. Paradigms are paramount in research because they allows a researcher to interpret the findings based on perspectives of the participants. According to Alharahsheh and Pius (2020), positivism and constructivism are two commonly used paradigms in quantitative and qualitative based studies. On the other hand, Allemang et al. (2022) and Kaushik and Walsh (2019) posit that for a mixed approach study a pragmatism paradigm is employed. This study incorporates both quantitative and qualitative methods and as a result a pragmatic paradigm was employed. Pragmatic paradigm is used to move away from the biases of using a positivism or constructivism paradigm hence pragmatism is used in studies that incorporate both approaches.

Research Approach

As mentioned above, this study adopted the pragmatic paradigm which relies on data collected to be of quantitative and qualitative nature.

Consequently, this study employed a mixed method approach. This approach is normally used to balance out the limitations of each method. A mixed method approach is also favored because of its ability to interweave both quantitative and qualitative approaches in one study to compensate for each methods biases (Dawadi et al., 2021). In the context of this study, quantitative data was collected through examining test scores of the learners and the qualitative data was sought using semi structured interviews from the grade 12 teachers teaching mathematics and EGD.

Research Design

This study adopted a mixed method approach and according to Dawadi et al. (2021), a mixed method study entails using one of the following designs:

(1) convergent parallel mixed-methods design,

(2) Explanatory sequential design, and

(3) Exploratory sequential design.

In the context of this study, an explanatory sequential design was adopted which deals with the collection and analysis of qualitative data first and followed by quantitative data. The researcher subjected teachers to semi structured interviews to gather their insight into the matter under investigation and the findings emerged from the qualitative data were supported by those generated from the test scores of learners hence this study adopted the explanatory sequential design.

Sampling and Population

Based on the objectives of this study, a convenience sampling was employed to select 15 mathematics and EGD teachers within uMgungundlovu District. Convenience sampling is an anon probability sampling technique where researchers intentionally select participants based on their characteristics and being readily available (Taherdoost, 2016). The same notion is echoed by McCombes (2019), that convenience sampling is used because it allows researchers to select participants who are readily accessible, saving time and resources. In this study, it enables easy access to four schools to get grade 12 mathematics and EGD teachers who are familiar with the topics of Euclidean geometry and ID. Convenience sampling was used because EGD is a very scarce subject that not many schools offer, consequently a researcher could only use four schools which offered EGD and mathematics. **Table 1** shows the biographical information of participants.

Table 1. Participants biographical information

SN	Teacher	G	Qualification	E
School A	Sabelo	M	Diploma in education	21
School B	Sipho	M	Secondary teacher diploma	15
School B	Mendy	F	BEd (technology education)	10
School C	Simon	M	BEd (technology education)	11
School C	Mandisa	F	BEd (technology education)	5
School D	Sizwe	M	BEd (technology education)	2
School A	Siphesihle	M	BEd (mathematics)	15
School A	Simphiwe	M	BEd (mathematics)	7
School A	Melisa	F	PGCE (mathematics)	4
School B	Mantombi	F	BEd (science)	26
School B	Sydney	M	NPDE (senior phase)	26
School B	Mbali	F	PGCE (mathematics/science)	13
School C	Senzo	M	BEd (mathematics & physics)	6
School D	Sbonga	M	ACE (mathematics)	27
School D	Melinda	F	PGCE (mathematics)	8

Note. SN: School name; G: Gender; M: Male; F: Female; & E: Experience

Data Collection Instruments

This study adopted a mixed method approach which means that data collected should be of quantitative and qualitative nature. Consequently, qualitative data was collected through semi structured interviews which were designed to get teachers insight about the practices they employ in teaching Euclidean geometry and ID. According to Hammer and Wildavsky (2018), interviews are the oldest qualitative method of collecting data which allow a verbal engagement between a researcher and the participants. This further allows participants to express their views and experiences freely without being restricted to a certain number of words or to a simple yes or no, which is common in closed ended questionnaires. Using semi structured interviews to collect data for this study was deemed suitable because they capture the specificity of a particular situation and in this study the specificities about the synergies in Euclidean geometry and ID. **Appendix A** and **Appendix B** shows questionnaires.

Document analysis was also used as a source of quantitative data. According to Morgan (2022), document analysis is the oldest way of collecting qualitative data. This method involves analyzing various types of documents including books, newspaper articles, academic journal articles, and institutional reports. Document analysis is further seen as the qualitative method of data collection which uses printed or electronic documents to respond to the objectives of the study. This study analyzed the test scores of 12 learners for each topic which resulted in 24 tests in total. These tests were considered relevant to expose if there are synergies within Euclidean geometry and ID.

Data Analysis

Quantitative data generated from the tests score was analyzed descriptively using the statistical package for social sciences. Mean and range were calculated to determine central tendency and the standard deviation to measure the spread of the test scores. Data was also analyzed using visual representation in the form of a clustered bar graph to visualize and interpret the relationship to determine synergies.

Data generated from the semi structured interview was analyzed using a thematic analysis. Thematic analyses is a qualitative research method of analyzing data that involves identifying and presenting patterns or themes in data. This form of analysis is drawn from the work of Braun and Clarke (2006) which put forth that this type of analysis should be done in six (6) steps. These steps as articulated by Braun and Clarke (2006) are, as follows: familiarizing 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 steps mentioned above.

Triangulation

Triangulation is a procedure used to gain validity in qualitative studies (Morgan, 2022). According to Check and Schutt (2011), Guion et al. (2011), and Punch and Oancea (2014), triangulation involves collecting data from multiple sources to ensure validity and trustworthy of the data. To ensure that validity and trustworthiness were maintained, this study collected data through semi-structured interviews and document analysis in the form of tests written by the grade 12 learners who are doing mathematics and EGD.

Ethics and Gaining Access

Ethical considerations are fundamental in research as they guide the responsible and respectful treatment of participants. In this study, first-year pre-service students participated as respondents. To ensure ethical compliance, the researcher obtained ethical clearance and gatekeepers from the DBE in KwaZulu Natal. This clearance allowed the research to proceed within established ethical guidelines.

Following ethical approval, a gatekeeper's letter was secured to gain permission to access the participants. Participants were approached and fully informed about the study's purpose and their rights. They were made aware that participation was entirely voluntary, with no monetary benefits, and that they had the freedom to withdraw from the study at any time without repercussions. Furthermore, their anonymity and confidentiality were safeguarded by using pseudonyms to protect their identities. These measures ensured that the research adhered to ethical standards, prioritizing the dignity, privacy, and autonomy of the participants throughout the study.

RESULTS AND DISCUSSIONS FROM SEMI-STRUCTURED INTERVIEWS

In this section we present the findings based on data collected through semi-structured interviews. This data was analyzed using thematic analysis which followed Braun and Clarke (2006) six steps of thematic analysis.

Table 2. Themes emerged from the findings

Theme	Name
Theme 1	Challenges with spatial visualization
Theme 2	Heavy reliance on past papers for examination preparation
Theme 3	Collaborative teaching community and external support
Theme 4	Access to training facilities for professional development
Theme 5	Positive attitude towards teaching

Data from the semi-structured interviews was used to provide responses to What teaching practices do mathematics and EGD teachers share when addressing Euclidean geometry and ID? To answer this research question, only five themes emerged as can be seen in Table 2. Table 2 reflects the themes that emerged from the data and how these relate to specific research questions.

Theme 1. Challenges With Spatial Visualization

From both set of teacher's responses, it was evident that learners are struggling in both ID and Euclidean geometry. Below are how EGD teachers responded:

Sabelo highlighted a significant challenge in teaching ID, stating:

> This is a very complicated topic for learners; they struggle to convert the given 2D view into a 3D drawing.

This sentiment was echoed by **Sizwe**, who elaborated on specific areas of difficulty:

> Most learners struggle with ID, particularly when required to draw non-isometric lines and the isometric circle.

Similarly, **Mendy** noted that the core issue lies in learners' inability to visualize the final outcome of a drawing:

> Learners fail to imagine how the given 2D view will look in 3D, which is the expected final version of the drawing.

Adding to this, **Sipho** emphasized the importance of visualization skills:

> Learners should be able to visualize the drawing before it is drawn, but they are struggling to do that.

The challenges are not exclusive to EGD. Mathematics teachers also reported similar difficulties, particularly in Euclidean geometry. For instance, **Sabelo** remarked:

> Euclidean geometry is very challenging and demanding for learners; as a result, most of them often fail this section.

In agreement, **Mbali** highlighted learners' difficulty in applying theorems effectively:

> It is hard to get learners to remember all the theorems and apply them appropriately.

Lastly, **Senzo** pointed out the lack of visual skills, which are essential for understanding Euclidean geometry, and described how visual aids have become an integral part of their teaching strategy:

> Learners are poor at visualizing the given diagrams, which helps them identify the theorems they need. As a result, I now teach using visual aids to boost their spatial visualization ability.

The above interview data from both EGD and mathematics show that learners are really struggling with ID and Euclidean geometry. The teachers indicated that students lack spatial visualization skills which assist them with imagination. This is in line with Mudaly and Narriadoo (2023) who found that spatial visualization is a very crucial skill in solving geometrical problems in mathematics. The lack of visualization in learners who are doing mathematics is further articulated by Sulistiowati et al. (2019) who put forth that learners are lacking the visualization which is the basis for understanding mathematics. Not only are mathematics learners poor in visualization EGD learners as well as expressed by EGD teachers when interviewed. This is supported by Khoza (2013) and Makgato and Khoza (2016) that most EGD learners are struggling in visualization which results in them performing poorly in EGD. Basically, spatial visualization is very crucial in all STEM programs (Khoza, 2017). Furthermore, Singh-Pillay and Sotsaka (2020) posit that students with well-developed spatial visualization ability can mentally transform or rotate 2D or 3D objects to whatever direction indicated through spatial visualization.

Theme 2. Heavy Reliance on Past Papers for Examination Preparation

Another theme that emerged is the reliance of both EGD and mathematics teachers on past examination papers to prepare students for assessments. This approach is seen as a strategy to familiarize learners with exam formats and expectations.

Simon explained their reliance on past papers:

> I rely heavily on past question papers for classwork, homework, and tests.

Mandisa similarly emphasized the use of past papers, specifically in EGD, as a tool to prepare learners:

> For assessment purposes in EGD, I normally use past papers so that learners become familiar with the style of the examiners.

This practice was echoed by mathematics teachers as well. **Melisa** highlighted the importance of using past papers to address the challenges learners face in Euclidean geometry:

> Euclidean geometry is very challenging for learners, so to ensure they can tackle common assessments, I use past papers for classwork, homework, and formal assessments.

The above responses are an indication that both EGD mathematics teachers rely heavily on past exam question papers to ensure that learners are well prepared when exams come and using these previous papers is a method of ensuring that learners are accustomed to examiners style of setting papers. The importance of using past papers is echoed Alhaji (2007) who conducted a study about digitizing past papers for easy access by students for future assessment purposes. The notion of using past papers to answer new questions is also mentioned in a study done by Shtok et al. (2012) who argue that past questions should be made available so that they can be used to answer new questions.

Theme 3. Collaborative Teaching Community and External Support

The third theme that emerged in addressing question 1, which explores the similarities in teaching and learning of ID and Euclidean geometry, is the role of collaborative teaching communities and external support. Teachers reported seeking assistance from colleagues at neighboring schools and receiving guidance from subject advisors to navigate the complexities of these topics.

Mandisa highlighted the importance of peer collaboration:

> Looking at the nature of ID and how complex it is, I usually seek aid from teachers at neighboring schools who are more knowledgeable.

Similarly, **Sizwe** emphasized the support provided by subject advisors and fellow teachers:

> Subject advisors, as well as other teachers, are always available to assist since this section is a little challenging to teach.

Mathematics teachers also shared their reliance on collaborative networks. **Melisa** described the role of professional learning communities (PLCs):

> There is a PLC program in place where all nearby mathematics teachers come together and share strategies.

Melinda echoed this sentiment, valuing the guidance of experienced colleagues:

> I get support from other teachers who are well-experienced in teaching this section.

The above responses from teachers show that both EGD and mathematics teachers seek assistance from other teachers who are more experienced and understand these concepts better since both sections are very demanding and often difficult to understand by the students. The teachers further mentioned that apart from neighboring teachers they also get assistance from the subject advisors. Collaborative teaching is very important in teaching and learning to ensure that learners get the best form of education from the content specialist (Vangrieken et al., 2015). Laal and Ghodsi (2012) further emphasize the importance of collaboration teaching among teachers which is of benefit to learners.

The second aim of conducting semi-structured interviews was to respond to research question 2 to gauge whether teachers can teach these crucial sections. Upon engaging with the teachers only two themes emerged which are

(1) access to training facilities and

(2) positive attitude towards teaching.

Theme 4: Access to Training Facilities for Professional Development

The first theme in answering research question 2 focuses on access to training facilities and professional development opportunities. Interviewed teachers indicated that they had attended training sessions designed to enhance their teaching of ID and Euclidean geometry.

Sipho shared their experience of attending training specific to EGD:

> Yes, I attended training back in 2016 held at George Campbell. Several topics were discussed, including ID.

This was echoed by **Mendy**, who also attended the training at George Campbell:

> Yes, I attended the EGD workshop camp at George Campbell. The training focused on difficult sections like ID and AD and was conducted over a weekend.

Mathematics teachers also confirmed receiving targeted training for teaching Euclidean geometry. **Sydney** described the scope and frequency of the workshops:

> I have attended a grade 10-garde 12 training workshop from 2018 to 2023, held twice a year for three days. In these workshops, all topics were covered.

The above responses show that the provisions has been put in place by schools and the DBE to ensure that teachers are adequately trained so that they can be able to teach these sections well. The findings above are in line with (Olivier, 2013, 2014) who reported that teachers were subjected to workshops aimed at developing their teaching skills. These training courses were conducted which a purpose of improving learners' performance in these crucial sections. The importance of training was recommended by Mlambo et al. (2023) who posit that the department of education should subject teachers to curriculum development workshop.

Theme 5. Positive Attitude Towards Teaching

The second theme highlights the positive attitudes demonstrated by teachers when teaching ID and Euclidean geometry. Despite acknowledging the difficulties these sections pose, teachers expressed enjoyment in teaching them.

Sabelo shared their enthusiasm for teaching ID, despite learners' challenges:

> I do enjoy teaching and assessing ID, but learners are struggling a lot.

Mathematics teachers echoed similar sentiments. **Mantombi** noted their enjoyment in teaching but expressed concerns about assessing learners:

> I enjoy teaching but not assessing. It is hard to get learners to remember all the theorems and apply them appropriately.

In agreement, **Melinda** shared their perspective on teaching Euclidean geometry:

> Yes, I do enjoy teaching Euclidean geometry, but most learners are struggling in this section.

The above responses are testament to struggles EGD and mathematics teachers are faced with when teaching these sections. But they still manage to teach it with a positive attitude which is very essential when teaching. To support the aforementioned claim Mlambo and Mkhwanazi (2024) put forth that the reason students are performing poorly is that teachers are teaching sections they don't like teaching. One of the lecturers interviewed by Mlambo and Mkhwanazi (2024) said *"I don't enjoy teaching this section because as a lecturer it is so difficult to watch students clueless about something you are teaching"* and another said *"I enjoy a little bit. This chapter is very difficult to teach"*. Therefore, it is very crucial for teachers to exhibit positive attitudes toward teaching as this can rub off on learners in a good way which will translate to them performing better.

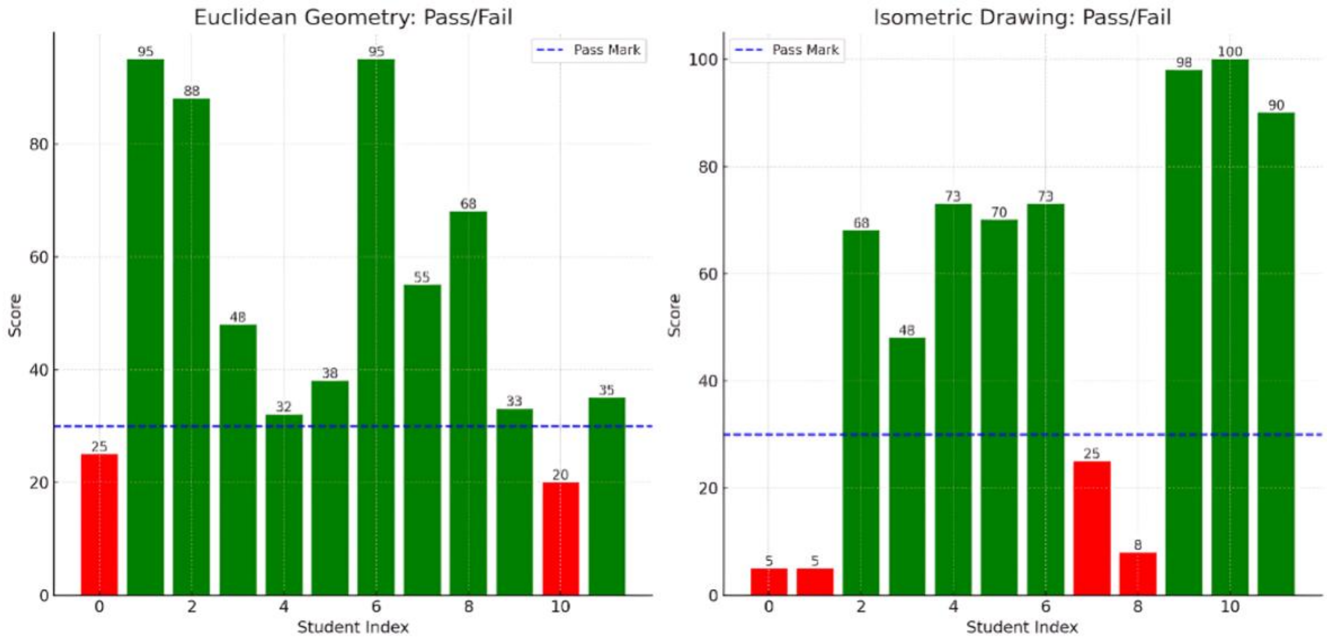

Figure 1. Euclidean geometry and ID test scores (Source: Authors' own elaboration)

RESULTS AND DISCUSSIONS FROM DOCUMENT ANALYSIS

Descriptive Analysis of the Findings

The mean score for Euclidean geometry is 52.46, which is just above the pass mark of 30. For ID, the mean is 55.00, showing relatively better performance overall. The standard deviation for Euclidean geometry is 27.399, reflecting moderate variability in learner scores. The standard deviation for ID is higher at 36.010, indicating a wider spread of scores and greater inconsistency in performance. The Euclidean geometry marks range is 75 and range for the ID is slightly higher at 95. Euclidean geometry has a minimum score of 20, showing that some learners failed but not as severely as in ID, where the minimum score is 5. A significant portion of learners excelled in ID, as reflected in the maximum score of 100. The higher standard deviation and broader range in ID indicate that while some learners excel, others struggle significantly more than in Euclidean geometry (**Table 3**).

Table 3. Descriptive analysis

		Euclidean geometry	ID
N	Valid	12	12
	Missing	0	0
Mean		52.46	55.00
Median		42.50	68.75
Standard deviation		27.399	36.010
Range		75	95
Minimum		20	5
Maximum		95	100

Visual Presentation of Grade 12 Learners' Performance

To provide a clear representation of how learners performed in each test, the bar graph in **Figure 1** depicts the scores obtained in Euclidean geometry and ID . The graph highlights individual test results, showcasing variations in performance across the two subjects. It serves as a visual summary of the learners' achievements, emphasizing areas of strength and difficulty.

Figure 1 presents the test scores of grade 12 learners who are enrolled in both mathematics and EGD. These scores were derived from tests written on Euclidean geometry and ID. As evident from **Figure 1**, 12 learners participated in the Euclidean geometry test, with the majority (83.33%, N = 10) achieving passing marks. Only a small fraction (16.67%, N = 2) performed poorly, as indicated by the red markers in **Figure 1**.

In contrast, performance in the ID test was slightly lower. While 66.67% (N = 8) of learners passed, 33.33% (N = 4) scored below the blue dotted line, signaling poor performance.

To further explore whether there is a synergy in learners' performance between these two tests, a scatter plot is presented in **Figure 2**, offering a visual representation of the relationship between the scores.

The scatter plot above highlights significant variability in the scores between Euclidean geometry and ID. For instance, some learners who performed well in Euclidean geometry scored poorly in ID, and vice versa. **Figure 2** also illustrates extreme differences, such as one learner scoring 25 in Euclidean geometry but only 5 in ID, while another scored 33 in Euclidean geometry and 98 in ID.

To further emphasize the extreme differences in learners scores the coefficient of determination (R^2 = 0.124), as shown on the scatter plot indicates that the

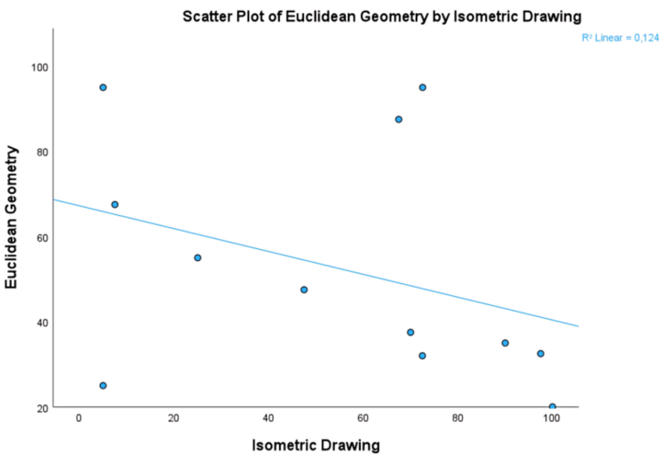

Figure 2. Scatter plot of Euclidean geometry by ID (Source: Authors' own elaboration)

Pearson correlation coefficient (r = - 0.35) reflects a weak relationship between the two subjects. This suggests that higher performance in one area does not necessarily correspond to higher performance in the other. On the other hand, statistical analysis (p = 0.27) revealed a statistical insignificance ($p > 0.05$), which exceeds the standard significance threshold of 0.05. This indicates that the observed relationship is not statistically significant and may be attributed to chance. In simpler terms, the value of *p* above represents that there is no relationship between learners' performance in ID and Euclidean geometry. Their performance that might show a significant relationship is due to chance.

As can be seen from the scatter plot in **Figure 2** the value of $R^2 = 0.124$, it means that 12.4% of the variation in EGD scores can be explained by mathematics scores (Euclidean geometry). The remaining 87.6% of the variation is due to other factors not captured by the relationship between these two variables. This basically means that there is a weak relationship between mathematics and EGD performance. In simple terms, it means that learner's performance in either subject does not influence the performance of another subject as this was also supported by the value of r = -0.35.

The above further suggests that Euclidean scores are not a strong predictor of ID scores, and other factors such as spatial visualization skills, teaching methods, resource availability may have a greater influence on EGD performance. These factors mentioned above might explain the remaining 87.6% variability since only a mere 12.4% is accounted for, which is a very low score to point out any positive relationship between two variables.

CONCLUSION

This study explored the synergies between Euclidean geometry and ID by examining shared teaching practices employed by grade 12 mathematics and EGD teachers. The findings reveal that while these topics are challenging for learners, there are notable similarities in how teachers approach their instruction.

Both mathematics and EGD teachers heavily rely on past examination papers as a preparatory tool, emphasizing familiarization with assessment styles and common questions. Additionally, collaboration among teachers, whether through PLCs or support from subject advisors, plays a significant role in addressing the complexities of these topics. Access to training workshops has also been instrumental in equipping teachers with strategies for teaching ID and Euclidean geometry, though there is room for more targeted interdisciplinary training.

Despite the difficulties learners face, teachers demonstrated a positive attitude toward teaching these sections, which is vital for fostering a productive learning environment. However, the lack of explicit synergies in learner performance across the two subjects suggests an opportunity for further exploration into interdisciplinary approaches that bridge the conceptual gaps between Euclidean geometry and ID.

In conclusion, the study underscores the potential for collaboration between mathematics and EGD teachers to enhance spatial visualization skills and align teaching practices. Fostering these synergies through structured training programs and shared teaching resources could significantly improve learner outcomes in both subjects.

Based on the findings, it can be concluded that while most learners performed well in both Euclidean geometry and ID, their performance in ID was slightly lower overall. The analysis of the scatter plot and statistical metrics revealed a weak negative correlation (r = -0.35) between the scores, indicating that higher performance in one subject does not necessarily align with higher performance in the other.

Furthermore, the lack of statistical significance (p = 0.27) suggests that the observed relationship between the two subjects may have occurred by chance and does not represent a meaningful synergy. These findings imply that although the subjects share some similarities, the skills required to excel in each might differ, highlighting the need for targeted instructional approaches to address the unique demands of both Euclidean geometry and ID.

Recommendations and Future Research

The study recommends fostering interdisciplinary collaboration between mathematics and EGD teachers through training programs and workshops to enhance their understanding of potential synergies between Euclidean geometry and ID. Curriculum developers should consider aligning the content of these subjects to explicitly highlight their connections, supported by integrated teaching materials and lesson plans. Teaching strategies that emphasize problem-solving, spatial visualization, and practical applications of geometric principles in EGD are encouraged. Additionally, targeted learner support programs and diagnostic assessments can address specific challenges and enhance learners' ability to connect concepts. For future research, it is suggested to explore learners' perceptions of the relationship between these topics, conduct longitudinal studies to track performance trends, and investigate the impact of integrated teaching approaches. Furthermore, studies could examine the role of digital tools like CAD software in bridging theoretical and practical aspects, and case studies in diverse school contexts could provide insights into how resource levels and teaching methodologies affect the development of synergies. As per the findings above other factors such as spatial visualization skills, teaching methods, resource availability may have a greater impact on learners' performance. Their future research must look at the above variables to seek synergies between these two complex topics.

Author contributions: PBM: conceptualization, software (SPSS), data curation, formal analysis (quantitative), investigation, methodology, project administration, resources, supervision, validation, writing original draft, writing-review & editing; **DTSS:** data curation, formal analysis (qualitative), writing literature review.Both authors have agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgments: The authors would like to thank all the school principals who allowed them to conduct this study within their schools and not to forget the teachers who were the source of data.

Ethical statement: The authors stated that the study was approved by the Institutional Research Ethics Committee at Durban University of Technology on 3 June 2024 with approval code IREC 024/24. Written informed consents were obtained from the participants.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Abdullah, A. H., & Zakaria, E. (2013). The effects of van Hiele's phase-based instruction using the geometer's sketchpad (GSP) on students' levels of geometric thinking. *Research Journal of Applied Sciences, Engineering and Technology, 5*(5), 1652-1660. https://doi.org/10.19026/rjaset.5.4919

Alhaji, I. U. (2007). Digitization of past question papers, dissertations and theses: A case study of 30 Nigerian university libraries. *The International Information & Library Review, 39*(3-4), 228-246. https://doi.org/10.1080/10572317.2007.10762752

Alharahsheh, H. H., & Pius, A. (2020). A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences, 2*(3), 39-43.

Allemang, B., Sitter, K., & Dimitropoulos, G. (2022). Pragmatism as a paradigm for patient-oriented research. *Health Expectations, 25*(1), 38-47. https://doi.org/10.1111/hex.13384

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Check, J., & Schutt, R. K. (2011). *Research methods in education*. SAGE. https://doi.org/10.4135/9781544307725

Dawadi, S., Shrestha, S., & Giri, R. A. (2021). Mixed-methods research: A discussion on its types, challenges, and criticisms. *Journal of Practical Studies in Education, 2*(2), 25-36. https://doi.org/10.46809/jpse.v2i2.20

DBE. (2011). *Curriculum and assessment policy statement: Grades 10-12 engineering graphics and design*. Department of Basic Education Pretoria.

DBE. (2021). *National senior certificate. Diagnostic report part 3: Technical subjects*. Government Printers Pretoria.

DBE. (2022). *National senior certificate. Diagnostic report part 3: Technical subjects*. Government Printers Pretoria.

Dube, N. V. (2016). *Teachers' experiences of the implementation of the mathematics curriculum and assessment policy statement at the further education and training (FET) phase: Case study* [Master's thesis, University of Fort Hare].

Govender, R. (2014). Rider strategies for solving school geometry problems. In *Proceedings of the 20th Annual National Congress of the Association for Mathematics Education of South Africa: Demystifying Mathematics*.

Guion, L. A., Diehl, D. C., & McDonald, D. (2011). Triangulation: Establishing the validity of qualitative studies: FCS6014/FY394, Rev. 8/2011. *Edis, 2011*(8), 3-3. https://doi.org/10.32473/edis-fy394-2011

Hammer, D., & Wildavsky, A. (2018). The open-ended, semistructured interview: An (almost) operational guide. In A. Wildavsky (Ed.), *Craftways* (pp. 57-101). Routledge. https://doi.org/10.4324/9780203794517-5

Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research. *Social Sciences, 8*(9), Article 255. https://doi.org/10.3390/socsci8090255

Khoza, S. D. (2013). Difficulties in sectional drawing: A case of student teachers at a university based in the Eastern Cape. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(4), 703-715. https://doi.org/10.12973/eurasia.2016.1220a

Khoza, S. D. (2017). Spatial skill's development and line-work improvement in learning the design process in a technology subject at a Johannesburg University. *International Journal of Engineering and Technology, 9*(4), 3020-3027. https://doi.org/10.21817/ijet/2017/v9i4/170904106

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of higher education, 6*(5), 26-41. https://doi.org/10.5430/ijhe.v6n5p26

Laal, M., & Ghodsi, S. M. (2012). Benefits of collaborative learning. *Procedia-Social and Behavioral Sciences, 31*, 486-490. https://doi.org/10.1016/j.sbspro.2011.12.091

Machisi, E. (2021). Grade 11 students' reflections on their Euclidean geometry learning experiences. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(2), Article em1938. https://doi.org/10.29333/ejmste/9672

Makgato, M. (2016). Difficulties of student teachers in the engineering graphics and design course at a South African university: Snapshot on sectional drawing. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(4), 703-715. https://doi.org/10.12973/eurasia.2016.1220a

Makgato, M., & Khoza, S. (2016). Difficulties experienced by pre-service teachers and lecturers in engineering graphics and design course at a university in South Africa. *International Journal of Educational Sciences, 14*(1-2), 157-166. https://doi.org/10.1080/09751122.2016.11890489

McCombes, S. (2019). Understanding different sampling methods. *Scribbr*. https://www.scribbr.com/methodology/sampling-methods

Mendoza, M. R. (2020). Detachable Rubik's cube as an innovative learning strategy in drafting courses. *International Journal of Scientific Research and Engineering Trends, 6*, 1787-1807.

Mlambo, P. B. (2024). Instructional practices by engineering graphics and design teachers: A focus on teaching and learning of isometric drawing. *Research in Social Sciences and Technology, 9*(2), 359-376. https://doi.org/10.46303/ressat.2024.41

Mlambo, P. B., & Mkhwanazi, M. S. (2024). Investigating factors contributing to poor performance in teaching and learning of N3 assembly drawing: A case of uMgungundlovu TVET College. *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: E-Saintika, 8*(1), 102-121. https://doi.org/10.36312/esaintika.v8i1.1479

Mlambo, P. B., Maeko, M. S. A., & Khoza, S. D. (2023). Factors contributing to resistance in the use of information and communications technology: A snapshot on engineering graphics and design teachers. *International Journal of Learning, Teaching and Educational Research, 22*(10), 271-289. https://doi.org/10.26803/ijlter.22.10.15

Morgan, H. (2022). Conducting a qualitative document analysis. *The Qualitative Report, 27*(1), 64-77. https://doi.org/10.46743/2160-3715/2022.5044

Mosia, M., Matabane, M. E., & Moloi, T. J. (2023). Errors and misconceptions in Euclidean geometry problem solving questions: The case of grade 12 learners. *Research in Social Sciences and Technology, 8*(3), 89-104. https://doi.org/10.46303/ressat.2023.23

Mthembu, S. G. (2007). *Instructional approaches in the teaching of Euclidean geometry in grade 11* [Master's thesis, University ofKwaZulu-Nata].

Mudaly, V., & Narriadoo, D. (2023). Solving word problems by visualising. *African Journal of Research in Mathematics, Science and Technology Education, 27*(1), 47-59. https://doi.org/10.1080/18117295.2023.2183612

Mudaly, V., & Reddy, L. (2016). The role of visualization in the proving process of Euclidean geometry problems. *PONTE International Journal of Science and Research, 72*(8). https://doi.org/10.21506/j.ponte.2016.8.13

Ndlovu, M. (2013). The learning of geometry as moving from one thinking level to the next: Revisiting van Hiele. In *Proceedings of the 19th Annual Congress of the Association for Mathematics Education of South Africa, vol. 1* (pp. 277-279). AMESA.

Olivier, W. A. (2013). Reflection on the training of teachers for the CAPS mathematics curriculum–A brief report. *SAMF*. https://www.samf.ac.za/en/caps-mathematics-report

Olivier, W. A. (2014). Reflections on the implementation of CAPS mathematics in the classroom. *SAMF*. https://www.samf.ac.za/en/advisory-commite-reports

Punch, K. F., & Oancea, A. (2014). *Introduction to research methods in education*. SAGE.

Samsudin, K., Rafi, A., & Hanif, A. S. (2011). Training in mental rotation and spatial visualization and its impact on orthographic drawing performance. *Journal of Educational Technology & Society, 14*(1), 179-186.

Shtok, A., Dror, G., Maarek, Y., & Szpektor, I. (2012). Learning from the past: Answering new questions with past answers. In *Proceedings of the 21st International Conference on World Wide Web*. https://doi.org/10.1145/2187836.2187939

Singh-Pillay, A., & Sotsaka, D. (2020). An exploration of first year pre-service engineering graphics and design teachers' spatial visualization ability at a university of technology. *Journal for the Education of Gifted Young Scientists, 8*(2), 681-690. https://doi.org/10.17478/jegys.639351

Sotsaka, D. T. S. (2015). *An exploration of the interface between grade 11 engineering graphics and design teachers' understanding of assembly drawing and their practice: A case study of the uThukela District,* *KwaZulu-Natal* [Master's thesis, University of KwaZulu-Natal].

Sotsaka, D. T. S. (2019). *Unmasking how pre-service engineering graphics and design teachers read and interpret assembly drawing at a university of technology: A case study in Umgungundlovu, KwaZulu-Natal* [PhD thesis, University of KwaZulu-Natal].

Sulistiowati, D., Herman, T., & Jupri, A. (2019). Student difficulties in solving geometry problem based on van Hiele thinking level. *Journal of Physics: Conference Series, 1157*, Article 042118. https://doi.org/10.1088/1742-6596/1157/4/042118

Tachie, S. A. (2020). The challenges of South African teachers in teaching Euclidean geometry. *International Journal of Learning, Teaching and Educational Research, 19*(8), 297-312. https://doi.org/10.26803/ijlter.19.8.16

Taherdoost, H. (2016). Sampling methods in research methodology: How to choose a sampling technique for research. *SSRN*. https://doi.org/10.2139/ssrn.3205035

Upadhe, S. N., Shinde, D. D., & Mugale, U. S. (2018). Ease of use experimentation of isometric template. *Procedia Manufacturing, 20*, 296-299. https://doi.org/10.1016/j.promfg.2018.02.044

Van Putten, S., Howie, S., & Stols, G. (2010). Making Euclidean geometry compulsory: Are we prepared? *Perspectives in Education, 28*(4), 22-31.

Vangrieken, K., Dochy, F., Raes, E., & Kyndt, E. (2015). Teacher collaboration: A systematic review. *Educational Research Review, 15*, 17-40. https://doi.org/10.1016/j.edurev.2015.04.002

APPENDIX A: QUESTIONNAIRE FOR EGD EDUCATOR

Table A1. Questionnaire for EGD educator (please complete the information needed below)

	Answer
Age	
Gender	
Number of years teaching in general	
Number of years teaching EGD	
Qualification/s	
Qualification in EGD (please specify)	
Have you attended any training in EGD for teaching and assessing ID? Please elaborate about the training and its duration	
How many periods of EGD do you teach per week in each grade?	
How many periods of EGD make up your workload?	
Do you teach other learning areas? Please list them	
Please indicate the number of period's these other learning areas contribute to your workload.	
Level on which you are employed, e.g., L1, L2, etc.	Level:
Nature of appointment: Permanent/temporary	

1. What is your understanding of ID? Please explain.

   ____

2. What are your views on teaching and assessing ID? Please elaborate.

   ____

3. Do you enjoy teaching and assessing learners in this section? Please explain.

   ____

4. How would you describe your practice of ID?

   ____

5. What type/types of classwork do you engage learners in or prefer to engage learner in when it comes to ID? Please elaborate.

   ____

6. Do you have the resources to engage in classwork as required by the CAPS document for ID? Please explain.

   ____

7. Do you feel adequately trained to implement the demands made on you in respect of the teaching and assessing in this section of work? Please elaborate.

   ____

8. What are your views on the content knowledge and skills that the grade 10, 11, and 12 EGD learners are expected to have/to know pertaining to ID? Please explain.

   ____

9. What strategies/method you do use to improvise for resources that are lacking at your school for the teaching and assessing of ID? Please explain.

   ____

10. Do you consult with students for resources? Please explain.

    ____

11. What support structures are available to you for the teaching and assessing ID? Kindly explain.

    ____

APPENDIX B: QUESTIONNAIRE FOR MATHEMATICS EDUCATOR

Table B1. Questionnaire for EGD educator (please complete the information needed below)

	Answer
Age	
Gender	
Number of years teaching in general	
Number of years teaching mathematics	
Qualification/s	
Qualification in mathematics (please specify)	
Have you attended any training in mathematics for teaching and assessing Euclidean geometry? Please elaborate about the training and its duration	
How many periods of mathematics do you teach per week in each grade?	
How many periods of mathematics make up your workload?	
Do you teach other learning areas? Please list them	
Please indicate the number of period's these other learning areas contribute to your workload.	
Level on which you are employed, e.g., L1, L2, etc.	Level:
Nature of appointment: Permanent/temporary	

1. What is your understanding of Euclidean geometry? Please explain.

2. What are your views on teaching and assessing Euclidean geometry? Please elaborate.

3. Do you enjoy teaching and assessing learners in this section? Please explain.

4. How would you describe your practice of Euclidean geometry?

5. What type/types of classwork do you engage learners in or prefer to engage learner in when it comes to Euclidean geometry? Please elaborate.

6. Do you have the resources to engage in classwork as required by the CAPS document for Euclidean geometry? Please explain.

7. Do you feel adequately trained to implement the demands made on you in respect of the teaching and assessing in this section of work? Please elaborate.

8. What are your views on the content knowledge and skills that the grade 10, 11, and 12 EGD learners are expected to have/to know pertaining to Euclidean geometry? Please explain.

9. What strategies/method you do use to improvise for resources that are lacking at your school for the teaching and assessing of Euclidean geometry? Please explain.

10. Do you consult with students for resources? Please explain.

11. What support structures are available to you for the teaching and assessing Euclidean geometry? Kindly explain.