Enhancing Mathematical Reasoning: The Perceived Influence of ICT Tools on Geometry Instruction

Lepheaa Justice Lepheana, Jabulani Sibanda

Article Info

Article History

Received:
13 July 2025
Accepted:
20 November 2025

Keywords

Mathematics
Mathematical reasoning
Geometry
ICT tools
GeoGebra

Abstract

Given the importance of improving mathematics performance, this study explored the perceived influence of ICT Tools, particularly GeoGebra, a software for enhancing Grade 6 Geometry Instruction, on Grade 6 Geometry instruction. The study contributes to the ongoing efforts to improve mathematics education in South Africa and beyond. This study employed the interpretivist paradigm, qualitative research approach, and case study design. Purposive sampling was used to select qualified and sufficiently experienced Grade 6 Mathematics teachers in Buffalo City Metro and Amathole East districts of the Eastern Cape. Online qualitative surveys were used to collect data on the perceived influence of ICT Tools on Grade 6 Geometry instruction. Data was analysed thematically. The major findings suggest that integration of ICT in Mathematics teaching is influenced by teacher readiness, resource availability, and technological knowledge. The findings also revealed that some teachers were familiar with GeoGebra, as an ICT tool that enhances learners' mathematical reasoning, but acknowledged the need for proper training to integrate GeoGebra in Geometry instruction. This study's recommendations include provision of support from Department of Education through teacher ICT training, ICT infrastructure, technological gadgets, technical assistance, and best practices in ICT teaching pedagogies.

Introduction

This study was triggered by underperformance in mathematics as revealed in the 2023 Trends in International Mathematics and Science Study (TIMSS), and the 2024 Department of Basic Education National Curriculum Statement (DBE) (NCS) diagnostic reports. The TIMSS 2023 assessment report showed that South African learners underperformed in international mathematics assessments (Reynolds et al., 2024). TIMSS 2023 reveals that South African learners scored below other nations of similar socioeconomic circumstances in mathematics, with the third lowest primary school score among 64 nations (Reynolds et al., 2024). In 2019, over 37% of South African Grade 5 learners displayed basic mathematical competencies, whereas 63% lacked basic mathematics understanding (Reddy et al., 2019). The most recent TIMSS 2023 report shows that South African Grade 5 learners continue to underperform, despite marginal improvement from 2019 to 2023, with the mathematics score rising from 389 to 397. Given the mathematics underperformance in South Africa, and the importance of mathematical reasoning in improving mathematics performance, this study explored the perceived

influence of ICT Tools on Grade 6 Geometry instruction, especially the potential of GeoGebra, a dynamic mathematics software, to enhance the teaching and learning of geometry in Grade 6 classrooms. By critically exploring the effectiveness of GeoGebra in developing learners' mathematical reasoning skills, this study contributes to the ongoing efforts to improve mathematics education in South Africa and beyond.

Literature Review

Mathematics has universal real-world application as we live in a world of numbers, equations, and computations which make mathematics a very important subject in the curriculum. Despite Mathematics being a crucial subject, in South Africa it is characterized by persistent underperformance. Figure 1 graphically represents the persistent mathematics underperformance.

	2020	2021	2022	2023	2024
% achieved at 30% and above	53.8	57.6	55.0	63.5	69.1
% achieved at 40% and above	35.6	37.6	36.0	43.6	47.9

Figure 1. Department of Basic Education National Senior Certificate Diagnostic Report 2024

Similarly, the most recent TIMSS 2023 report shows that South African Grade 5 learners continue to underperform, despite some insignificant improvement from a score of 389 in 2019 to 397 in 2023. Table 1 shows the marginal improvement.

Table 1. South African TIMSS Overall Achievement Rates in Mathematics (Percentage)

South Africa (5)			
2023	362 (3.5)	355 - 369	
2019	374 (3.6)	367 - 381	12 (5.0) ▲
2015	376 (3.5)	369 - 383	14 (5.0) ▲

The underperformance necessitates early intervention to enhance learners' mathematical reasoning as Sulianto et al. (2020) assert that weak mathematical reasoning is a major contributor to learners' poor mathematics performance and impacts learners' problem-solving skills. Mathematical reasoning is necessary for mathematical understanding (Herbert & Williams, 2023). One of the ways to enhance mathematical reasoning is mastering the art of teaching geometry. Hassan et al. (2020) posit that geometry is a fundamental part of the mathematics curriculum essential for developing mathematical reasoning and problem-solving skills. However, geometry can only improve learners' mathematical reasoning if it is taught effectively, usually through the integration of ICT tools like Khan Academy, Photomath, Prodigy, Shapes Toddler, Montessori, Geoboard, GeoGebra etc. GeoGebra stands out as a vital ICT tool in geometry teaching, due to its engaging and flexible capabilities, combining geometric visual and verbal representations to improve mathematical reasoning.

Using technology and software like GeoGebra can help make mathematical concepts more visual, concrete, and intuitive (Thomas & Adebowale, 2023). The successful integration of ICT in education is partly determined by teachers' perceptions. A recent study by Arhin et al. (2024) looked at 90 teachers' perceptions of the effectiveness of ICT in mathematics and their willingness to use it. The teachers recognised the potential advantages associated with ICT integration; however, they were concerned about technological problems, a lack of resources, and inadequate training. In the same vein, several studies have demonstrated that digital technology users encounter difficulties, especially regarding limited bandwidth and internet connectivity (Golding & Batiibwe, 2020; Kibirige, 2023; Nyakito et al., 2021).

Research has been conducted on how secondary school learners feel about GeoGebra's effectiveness for teaching and learning geometry (Shadaan & Eu, 2013; Mthethwa et al., 2020; Batiibwe, 2024), and focus has been on secondary schools. There is a dearth of studies on GeoGebra integration in primary schools (Scippo et al., 2025; Yunianto & Jarvis, 2025; Lavicza et al., 2025) none of which focus on Grade 6. The present study focused on the perceived influence of GeoGebra in the teaching of geometry in Grade 6, particularly its potential to improve geometry instruction and enhance mathematical reasoning in both urban and rural classrooms. Grade 6 marks a transition from intermediate to senior phase, and learners should have learnt the fundamentals of geometry by the time they leave intermediate phase. Teachers in urban and rural locations were also selected to see if they had comparable viewpoints. The overarching research question guiding this study was the perceived influence of GeoGebra on the teaching of geometry in Grade 6 for improving mathematical reasoning.

The successful integration of ICT may be compromised by several barriers and Alzankawi (2024) identifies some of them as teachers' lack of frameworks that link theory to practice, insufficient infrastructure, and inadequate teacher preparation. In the same vein, Ardina et al. (2025) note that, poor internet connectivity, particularly in underprivileged areas, presents serious issues for many teachers. In addition, the integration of ICT tools is made more difficult by limited access to devices and inadequate educational resources (Kunjiapu et al., 2025). Due to insufficient training, a lack of resources, or a lack of exposure to evidence-based instructional practices, many pre-service and in-service teachers locally find it difficult to successfully integrate technology with traditional teaching approaches (Ardina et al., 2025). It can also be hampered by significant infrastructural and technical hurdles, particularly in under-resourced areas (Mokgadi & Moloi, 2025).

Additionally, inadequate technical support and the absence of teacher training further exacerbate these challenges, preventing schools from fully exploiting ICT's potential (Murungi et al., 2018). According to Alenezi and Alsadoon (2022), teachers' ability to effectively integrate ICT into their professional development is heavily influenced by their prior knowledge, technology confidence, and institutional willingness to supply resources. These barriers underscore the importance of structured ICT training programs that cover both the technical and pedagogical components of digital learning tools (Chakraborty, 2023). To effectively integrate technology in mathematics education, teachers must combine content understanding, pedagogical tactics, and digital tools. The TPACK framework provides a lens for understanding teachers' pedagogical thinking while creating technology-enhanced lessons (Priyanda et al., 2025) and is discussed next.

Theoretical Framework

This study is informed by Technological Pedagogical Content Knowledge (TPACK) theory by Koehler and Mishra (2005), complemented by Davis' (1986) Technology Acceptance Model (TAM). Teachers with TPACK knowledge may provide more engaging and dynamic learning experiences, resulting in increased motivation and learner engagement in a world where digital tools have a broad impact on many aspects of human life (Filina et al., 2024). In this study, the TPACK framework enabled assessment and mapping of how teachers integrate ICT tools such as GeoGebra into various knowledges. It provides the necessary pedagogy along with guidelines for efficient technological integration, and the different knowledges that the teacher possesses, both before and during teaching. The TAM, as one of the most used models for analysing user acceptance behaviour, focuses on behavioural intentions of a teacher to either accept and integrate ICT tools or not. According to TAM, a person's level of technology acceptance is determined by its perceived usefulness (PU), perceived ease of use (PEOU), attitude, and behavioural intention to use ICT. This study explored the perceived influence of ICT Tools on Grade 6 Geometry Instruction to enhance mathematical reasoning. The TPACK allowed the investigation of teacher knowledge when utilising ICT tools, such as GeoGebra and other Mathematics software in teaching. It also enabled the researchers to make sense of how these TPACK components are integrated in teaching and requisite pedagogical knowledge and technological integration knowledge. On the other hand, TAM acknowledges that behavioural intention's ability to use a certain technology is a significant determinant of its actual utilisation. These technologies may be beneficial to people yet challenging to use, which could hinder their adoption or integration in in schools. It is important to note that one of the most important indicators of technology adoption is usage, hence, the positive perceptions of ICT integration have a potential of enhancing the ICT integration in education, particularly for critical subjects such as mathematics. Thus, if using ICT increases their efficiency or quality of instruction, teachers will use it (Lee, Kozar & Larsen, 2003). Consequently, the use of educational technology could fail if the Department of Basic Education does not effectively support its use in the classroom and if teachers are not prepared to use it for both teaching and learning (Hsu, 2016) (see Figure 2).

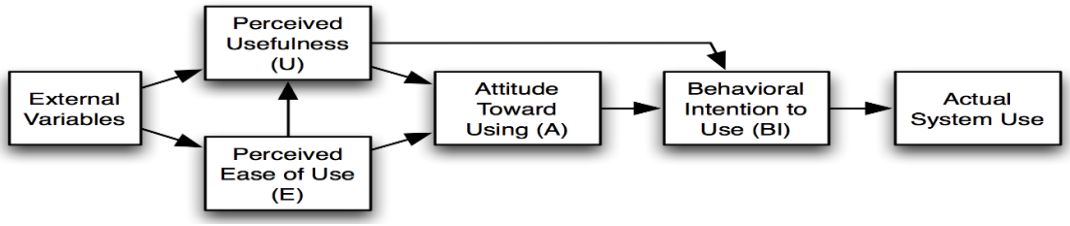

Figure 2. Technology Acceptance Model (Davies et al., 1989)

Figure 2 clarifies the relationship between and among the components of the model and their ultimate effect on actual use or implementation.

Methods

This study adopted the interpretivist paradigm, an appropriate paradigm because of its flexibility in data

gathering and analysis methods (Linake et al., 2023). It enabled a better understanding of teachers' subjective experiences, perceptions, and interpretations through an online qualitative survey (open-ended). Interpretivists believe that "reality can be diverse for different individuals and thus, subjective" (Alharahsheh & Pius, 2020:42). The qualitative research approach was used as a naturalistic inquiry approach that seeks a thorough understanding of social events in their natural setting to comprehend people's experiences and views (Creswell & Clark, 2018). The approach allowed for the uncovering of in-depth, intricate social events within participants' natural context, to provide comprehensive understanding of individuals' experiences and perspectives on the perceived influence of ICT Tools on Grade 6 Geometry instruction to enhance mathematical reasoning in their natural setting.

Further, a case study research design was used. Lepheana and Chisango (2022) note that a case study helps to explain the complex nature of a setting. My setting was complex as this study was done in two districts, one in urban Buffalo City Metro (BCM) district and one in rural area Amathole East (AE) district, with all Grade 6 Mathematics teachers being the study population. This case study intended to provide useful insights into the problems and opportunities of integrating technology into mathematics instruction. Participants were selected from 4 schools in the two districts and reflected the geographic diversity of the two districts to find if the findings were comparable. Eight Grade 6 Mathematics teachers were purposively selected but only 6 participated, three from BCM District (2 from same school and 1 from a different school) and three from AE District (2 from the same school and 1 from a different school). The initial aim had been to get at least 2 Grade 6 mathematics teachers from each school but, unfortunately, two teachers withdrew. Participants were selected on the basis that they had majored in mathematics in their teacher education, they had at least 3 or more years mathematics teaching experience, and they were computer literate. An online qualitative survey with open-ended questions was administered to gather participants' ideas, experiences, attitudes, and practices of using ICT tools when teaching Grade 6 Geometry. The codes A, B, C, D, E and F were used to identify the participants. Teacher A, B and C were all from BCM district whereas teacher D, E and F were from AE district.

Qualitative surveys were thematically analysed (inductive and deductive analysis). Inductive analysis focused on themes emerging from the data without preconceptions, whereas deductive analysis focused on existing theories that served as guides for codes and themes. The aim was to establish whether Grade 6 Mathematics teachers used ICT tools, including GeoGebra, in their geometry instruction, and if so, how they employed them.

Ethics and Trustworthiness

As part of a larger study for a qualification, ethical clearance was provided by the relevant institution prior to obtaining permission from the Department of Education to conduct the study in selected primary schools. Informed consent was granted by the principals and participating teachers. Any information that could reveal participants' identity was erased from all documents in the study report. This included the participants' identities as well as the names of their schools (Cohen et al., 2011). Participants' confidentiality and privacy were protected as codes (Teacher A, B, C, D, E, F) were used in place of their real names in this study. To maintain trustworthiness, credibility, confirmability, transferability and dependability were considered. Member checking

provided credibility to the study, and its transferability was achieved by carefully selecting participants, conducting extensive investigation, and then thoroughly analysing the data. Confirmability emerged from detailed records of data collection, coding decisions, and analytic memos; and dependability from sufficient detail that allowed for the replication of the study.

Results

The section below presents findings from the identified themes that matched the open-ended qualitative survey. The themes were:

- Barriers in acquiring ICT in the classroom
- Simplicity of utilising ICT to teach mathematics
- Teachers' familiarity with ICT tools and software
- Teachers' experience in integrating ICT tools to teach mathematics, and
- Teachers' familiarity with GeoGebra, GeoGebra's effectiveness in teaching geometry

Data is presented and discussed under each of the themes.

Barriers to ICT Integration in the Classroom

The participants identified various challenges hindering effective ICT integration in their teaching practices. The responses highlighted three primary categories of barriers: technical, financial, and pedagogical.

> Teacher A: *"Technical difficulties, equipment malfunctions, insufficient internet connectivity, limited budget for ICT infrastructure and insufficient funding for teacher training."*
>
> Teacher B*: "No, not at all because I'm familiar with these things. It was not my first time using them."*
>
> Teacher C*: "Yes, I had been challenged by having limited access to computers and network issues hence I am located in a rural area, which made it hard to use the tool."*
>
> Teacher D*: "Yes, internet connectivity issues, lack of software/hardware resources, and insufficient practical skills are always the most efficient barriers in acquiring ICT in the classroom."*
>
> Teacher E:*"Yes, lack of resources."*
>
> Teacher F: "*Yes, because the school doesn't have resources to support ICT*."

Findings show that most teachers experienced significant challenges in acquiring and integrating ICT into their classrooms. Common challenges were poor internet connectivity (Teachers A, C, D), limited access to devices and infrastructure (Teachers A, C, D, E, F), and financial constraints affecting both equipment and teacher training (Teacher A). (Teacher D) also mentioned insufficient practical ICT skills as a barrier, while only (Teacher B) reported no difficulties, citing prior familiarity with the tools. These findings suggest that contextual factors hinder ICT integration. Tondeur et al. (2017) emphasise that successful ICT implementation in schools depends, not only on teacher competence, but also on systemic support, including infrastructure, ongoing professional development, and policy alignment. Likewise, Mokgadi and Moloi (2025) highlight that integration of ICT in education is hampered by significant infrastructural and technical hurdles, particularly in under-resource areas. The absence of suitable infrastructure, including restricted internet access, insufficient

multimedia tools, and unstable electrical supply, impedes the effective use of digital learning tools (Kassutto et al., 2021). Additionally, inadequate technical support and the absence of teacher training further exacerbate these challenges, preventing schools from fully exploiting ICTs potential (Murungi et al., 2018). Similarly, studies by Buabeng-Andoh (2012) and Pelgrum (2001) highlight that access, training, and technical support are among the most persistent barriers to effective ICT use in developing country contexts. In the same vein, Hammou (2021) assert that the unavailability or deficiency in training in digital literacy and absence or insufficiency in proper pedagogical training in methodologies and strategies of using ICT in the classroom were apparent hurdles to implementing new educational technology into classroom practices. The process of integrating ICT into classroom teaching practices depends on the amount of time that teachers must develop and conduct classes that partially or completely integrate ICT (Hammou, 2021).

Simplicity of Utilising ICT to Teach Mathematics

Under this theme is the reports on diverse perspectives from participants:

> Teacher A: *"It is not simple because of the following: Pedagogical integration, Balancing technology use, Teacher training, and Digital divide."*
>
> Teacher B: *"Yes, it's simple to use. For example, in the topic that I was doing, which is geometry, it was so easy to draw shapes/polygons using GeoGebra, and it saved me a lot of time. I just displayed the shapes on the paperboard in less than a minute. So, it saves time and also makes mathematics very simple and easy to understand."*
>
> Teacher C: *"It is simple only if teachers can be given more time to practice using the tool so that they can be familiar with it."*
>
> Teacher D: *"Using ICT in teaching, particularly Mathematics, can be both simple and complex, depending on various factors. Simple aspects: Using digital tools can enhance learner engagement and understanding, and ICT can facilitate visual learning. Complex aspects: Effective integration requires teachers to have sufficient technical skills and training, selecting appropriate digital tools, ensuring equitable access, and balancing technology use with traditional methods."*
>
> Teacher E: *"Yes, actually ICT is easily integrated as long as you have the skill and resources."*
>
> Teacher F: *"No, if one does not have basic ICT skills."*

Teachers gave different perspectives on the ease with which ICT is used to teach mathematics. Some teachers found ICT technologies easy to use, citing specific advantages like time savings (Teacher B) and increased learner engagement (Teacher D). Others, however, identified problems, such as the need for teacher training (Teachers A and D), adequate practice time (Teacher C), and possession of basic ICT skills (Teacher F). Teacher D offered a comprehensive perspective, pointing out that ICT integration can be both simple and hard, depending on technical abilities, tool choices, and accessibility. (Teacher E) emphasised the necessity of having the right skills and resources. These findings imply that the ease of adopting ICT in mathematics education is dependent on several factors, including teacher preparedness, access to resources, and technical abilities. These findings resonate with the Technological Pedagogical Content Knowledge (TPACK) theory, emphasising the importance of teacher knowledge and skills in integrating technology into teaching (Koehler & Mishra, 2009).

The findings also revealed that pedagogical integration is a significant barrier to ICT integration. This view is backed by Adelabu et al. (2019) who suggest that integrating computer technology into geometry education is crucial for addressing 21st century challenges (Suparman et al., 2024). The findings also emphasise the significance of having the requisite skills and resources for a success integration of ICT in teaching. The literature also revealed that, a successful integration requires a pedagogically driven strategy that prioritises teaching design over technology functioning (Mwingirwa & Miheso-O'Connor, 2016).

Teachers' Familiarity with ICT Tools and Software

When asked to identify ICT tools and software they are familiar with, teachers provided a diverse range of responses. These responses were:

> Teacher A: *"Moodle, Blackboard, Microsoft teams, Zoom, Mathematica, Wolfram Alpha, Mathway, Graphing calculator, and GeoGebra."*
>
> Teacher B: *"GeoGebra, Khan Academy, Mathway, edX, Moodle, Blackboard."*
>
> Teacher C: *"GeoGebra, Microsoft office (word, excel, PowerPoint) and Google Form."*
>
> Teacher D: *"GeoGebra, Graphing Calculator, Mathematica, MATLAB, Mathway, Microsoft Mathematics, and Autodesk."* Online tools comprised *"Khan Academy, Mathway, Wolfram Alpha, Desmos, Math Open Reference, IXL, and CK-12."* Applications included *"Photo math, Math Tricks, Geometry Pad, Math Games, and Khan Academy, online whiteboards, virtual manipulatives, spreadsheets, presentation software, and learning management systems."*
>
> Teacher E: *"GeoGebra, Excel, Access, Word, Teams, Zoom, Skype, PowerPoint."*
>
> Teacher F: *"Computers, Smartphones, and printers."*

The findings showed that teachers were familiar with a variety of digital tools and resources. Some teachers were familiar with GeoGebra, Mathway (Teachers A, B, and D), and Microsoft Office application such as Microsoft word etc (Teachers C and E). Teachers A and B cited learning management systems such as Moodle and Blackboard. (Teacher D) identified an extensive list of mathematics-related tools, internet resources, and applications. In comparison, (Teacher F) only included basic hardware and equipment such as computers, smartphones, and printers. The teachers' responses indicated various patterns, comparisons, and differences across the ICT tools they knew.

Five of the six teachers mentioned GeoGebra, indicating a widespread familiarity of this program, underscoring the importance of this ICT tool in teaching mathematics and that, hence most teachers are familiar with this ICT tool, they are likely can integrate it in their teaching to enhance mathematical reasoning and understanding. This is backed up by literature, highlighting that, GeoGebra is the first among other ICT tools which are currently being explored to achieve integration of ICT in education", (Em Roman and Emerson, 2020). In the same view, studies by Prieto-González, et al. (2023) and, Thomas and Adebowale (2023) underscore that, using technology and software like GeoGebra can help make mathematical concepts more visual, concrete, and intuitive. Similarly, studies by Chytas et al., (2024) found that GeoGebra's visual representations help learners better understand complicated mathematical concepts.

Teachers' Experience in Integrating ICT Tools to Teach Mathematics

A sizable number of teachers reported no experience.

Teacher A stated, *"No."*

Teacher B responded, *"No, I have never used one."*

Teacher C said, *"No, I have never used any ICT tool to teach Maths because my school doesn't have these technologies stuff, but I have witnessed people using them."*

Teacher D demonstrated expertise by saying: " *Yes, GeoGebra (geometry and algebra) and this is how you can use it: Download and install GeoGebra from their website, Launch GeoGebra and choose a perspective (e.g., Algebra, Geometry, or 3D)."*

Teachers E said, *"Yes, I have used a PowerPoint presentation to present my lessons and display geometric shapes."*

Teacher F *simply stated, "Yes, PowerPoint slides."*

The findings reveal that teachers have various levels of experience using ICT tools to teach mathematics. (Teacher A and Teacher B) reported no experience, with (Teacher B) specifically indicating that they had never used one. (Teacher C) likewise had no experience, attributing it to a lack of technology in their school, but did remark seeing others use ICT tools. In contrast, (Teacher D) displayed proficiency with GeoGebra, providing a full description of how to use the tool, including downloading and installing the software, creating objects, and modifying them. (Teacher E) described using PowerPoint presentations to give lessons and display geometric shapes, whereas (Teacher F) just claimed that they had utilised PowerPoint slides. (Teacher D) demonstrates advanced skills in utilising a specific mathematics tool and others having little or no experience. The findings demonstrate the gap in ICT tool usage in teaching, among teachers, with only minority of these teachers who had used ICT tools in their teaching, this highlights a need for enhanced ICT integration. The findings further demonstrated a few themes, comparisons, and contrasts in how these teachers used ICT resources to teach mathematics. Most teachers (5 out of 6) reported utilising ICT tools, with GeoGebra being the less often mentioned. This shows that there must be a shift towards the use of digital tools such as GeoGebra in mathematics teaching, hence, this ICT tool is very important and relevant in teaching topics like algebra, geometry, statistics etc, this software also improves learners' involvement and mathematical reasoning. This is backed up by literature, as it reveals that, the use of technology, such as GeoGebra, along with traditional/conventional methods that are "embedded in culture, human experience, and social interaction" (Hechter, 2020, p. 5) ease its learning. Similarly, Korenova et al. (2025), assert that, the usage of software such as GeoGebra has considerable potential to improve teaching methods while also increasing learners' involvement and knowledge, this potential is particularly important in primary education, where innovative teaching pedagogies can have an important effect on learners' long-term mathematical performance.

Teachers' Familiarity with GeoGebra

To gauge teachers' familiarity with GeoGebra, a versatile ICT tool for mathematics education, they were asked if they knew GeoGebra.

Teacher A responded succinctly, *"No."*

Similarly, Teacher B stated, *"No, I don't have much knowledge."*

Teacher C demonstrated a thorough understanding, noting, *"Yes, I'm familiar with GeoGebra. GeoGebra is a free mathematics software, it combines Geometry: Interactive 2D and 3D geometry, including points, lines, circles, and polygons."*

Teacher D elaborated *" Yes, I know that GeoGebra is an incredibly powerful tool for math and science exploration, education, and research."*

Teacher E noting, *"Yes, GeoGebra is used for creating interactive lessons in mathematics such as plotting graphs of 3D function and drawing shapes."*

Teacher F stated, "*Yes, it said that it us used to teach topic like geometry, algebra, measurement etc."*

The findings indicated a common pattern: familiarity with GeoGebra. All the teachers who replied positively (Teachers C, D, E, and F) identified GeoGebra as the ICT tool they are familiar with. This shows that GeoGebra is a well-known and recognised tool in teaching mathematics. Another pattern emerged: varying levels of expertise about GeoGebra. The teachers showed varied levels of understanding, from a quick reference (Teachers C, D and E) to a full discussion of its qualities and capabilities. The findings reflect differences in the teachers' exposure to and familiarity with GeoGebra, underscoring a gap in GeoGebra knowledge among teachers, with some demonstrating advanced understanding while others have little understanding. Fndings reveal that, if these teachers are familiar with GeoGebra, getting a proper training may enable them to integrate it in their teaching of different mathematics topics. Literature is consistent with this, as Korenova et al. (2025) argue that GeoGebra, a dynamic mathematics software that combines geometry, algebra, and calculus, is an effective tool for teaching complex mathematical concepts in an interactive and visually engaging manner, in the classroom, it enables learners to visualise and manipulate mathematical objects, enhancing learners understanding of the subject matter.

GeoGebra's effectiveness in teaching geometry

To gauge teachers' perceptions of GeoGebra's usefulness in teaching Geometry, they were asked if they viewed the ICT tool as for teaching geometry effectively.

Teacher A: *"No."*

Teacher B: *"I think it's useful as education is moving slowly to advanced technology in our days."*

Teacher C: *"I view GeoGebra as an extremely useful tool in teaching geometry because it allows learners to explore and interact with geometric shapes in a visual way making complex ideas more accessible and engaging."*

Teacher D: *"I view GeoGebra as an extremely useful ICT tool in teaching geometry. Reasons: Interactive Visualisations: - GeoGebra allows learners to create and manipulate geometric objects, making complex concepts more accessible and engaging. Dynamic Exploration: -Learners can experiment with different scenarios, parameters, and variables, promoting deeper understanding and discovery."*

Teacher E: *"Yes. It is very useful for teaching geometry because it allows learners to see shapes and*

transformations, mostly for learners who learn better by using their sense of sight than always listening to their teacher. It helps learners understand the concepts more clearly compared to the traditional methods."

Teacher F: "*Yes, in fact, any ICT tool is very useful hence it makes a lesson very catchy and interesting to learners."*

The findings demonstrate that teachers have different perspectives on GeoGebra's usefulness in geometry education. (Teacher A) replied simply disagreed, demonstrating a lack of interest, knowledge or experience. (Teachers B, C, D, E and F) on the other hand, see GeoGebra as a valuable tool, noting advantages such as interactive visualisations, dynamic exploration, and improved knowledge and effective ICT tool in delivering geometry lesson. With (Teacher C and D) emphasising GeoGebra's capacity to make complex topics more accessible and entertaining, with (Teacher D) providing a thorough overview of the program's capabilities and benefits. (Teacher E) stated that GeoGebra's visual aspect helps learners understand concepts more clearly, whilst (Teacher F) emphasised the relevance of ICT tools in making mathematics lessons more entertaining. (Teacher B) also acknowledged the need of integrating technology into teaching. These findings reflect the range of perspectives on GeoGebra's utility, with most teachers acknowledging its potential to improve teaching and learning in teaching geometry and other mathematics topics. The literature is consistent with these findings, for instance, Uwurukundo et al., (2022a, 2022b, 2022c) found that GeoGebra significantly improved learners' attitudes towards learning 3-D geometry compared to traditional methods, indicating its effectiveness in changing learners' perspectives. Similarly, study by Schmid and Korenova (2024) highlight that traditional methods of teaching geometry frequently rely heavily on "pencil and paper" techniques; however, this approach may not effectively convey the dynamic and interconnected nature of geometric concepts, resulting in difficulties visualising and comprehending abstract relationships, and learners may struggle to apply their knowledge in practical contexts, to solve these issues, integrating innovative technologies like GeoGebra can improve geometry teaching and learning.

Discussion

The study's findings have several demonstrations, for instance, most teachers encountered significant barriers while trying to acquire and use ICT into their lessons. Poor internet connectivity (Teachers A, C, D), restricted access to devices and infrastructure (Teachers A, C, D, E, F), and financial limitations impacting both teacher training and equipment (Teacher A) were prevalent barriers. While only Teacher B reported no issues, citing past familiarity with the tools, Teacher D also cited a lack of practical ICT skills as a barrier. These results imply that ICT integration is hindered by contextual barriers. This is consistent with Tondeur et al.'s (2017) idea that fundamental support, such as infrastructure, continuous professional development, and policy alignment, is just as important to the successful adoption of ICT in schools as teacher competency. The absence of suitable infrastructure, including restricted internet access, insufficient multimedia tools, and unstable electrical supply, impedes the effective use of digital learning tools (Kassutto et al., 2021). Teachers expressed differing opinions about how simple it is to teach mathematics using ICT. Some teachers reported that technological tools were simple to use, pointing to benefits such improved engagement among learners (Teacher D) and time savings

(Teacher B). However, some pointed to issues like the necessity of teacher preparation (Teachers A and D), sufficient practice time (Teacher C), and having fundamental ICT skills (Teacher F). Teacher D provided a thorough viewpoint, pointing out that, depending on knowledge of technology, tool selection, and accessibility, ICT integration can be both easy and challenging. (Teacher E) stressed how important it is to have the appropriate tools and abilities. These results suggest that several factors, such as teacher readiness, resource availability, and technical proficiency, influence how simple it is to implement ICT in mathematics teaching. This findings resonates with the Technological Pedagogical Content Knowledge (TPACK) theory, emphasising the importance of teacher knowledge and skills in integrating technology into teaching (Koehler & Mishra, 2009). The findings also revealed that pedagogical integration is a significant barrier to ICT integration. This view is backed by Adelabu et al. (2019) who suggest that integrating computer technology into geometry education is crucial for addressing 21st century challenges (Suparman et al., 2024).

The results show that different teachers have different levels of experience teaching mathematics using ICT technologies. Both Teachers A and B said they had no experience, with Teacher B saying they had never used one. (Teacher C) did not have any experience either, citing a lack of technology in their school. However, she did observe others using ICT tools. Conversely, (Teacher D) demonstrated mastery of GeoGebra by giving a thorough explanation of how to use the tool. While Teacher F only stated that they had used PowerPoint slides, Teacher E explained how they used them to teach classes and show geometric shapes. When using a certain mathematical tool, (Teacher D) demonstrates outstanding skills whereas others have little to no experience. The findings further demonstrated a few themes, comparisons, and contrasts in how these teachers used ICT resources to teach mathematics. Most teachers (5 out of 6) reported utilising ICT tools, with GeoGebra being the less often mentioned. This shows that there must be a shift towards the use of digital tools such as GeoGebra in mathematics teaching, hence, this ICT tool is very important and relevant in teaching topics like algebra, geometry, statistics etc, this software also improves learners' involvement and mathematical reasoning. backed by Korenova et al. (2025), who assert that, the usage of software such as GeoGebra has considerable potential to improve teaching methods while also increasing learners' involvement and knowledge, this potential is particularly important in primary education, where innovative teaching pedagogies can have an important effect on learners' long-term mathematical performance.

The findings revealed a similar pattern: familiarity with GeoGebra. All the teachers that responded favourably (teachers C, D, E, and F) mentioned GeoGebra as an ICT tool they are familiar with. This demonstrates that GeoGebra is a well-known and accepted tool for teaching mathematics. Another pattern emerged: various levels of GeoGebra knowledge. The teachers demonstrated varying levels of knowledge, ranging from a fast reference (Teachers C, D, and E) to a thorough discussion of its characteristics and capabilities. These findings reflect gaps in teacher experience to and familiarity with GeoGebra, highlighting a knowledge gap among teachers, with some displaying advanced understanding and others having limited understanding. This finding reveals that, if these teachers are familiar with GeoGebra, getting a proper training may enable them to integrate it in their teaching of different mathematics topics. The literature is consistent with this, as Korenova et al. (2025) argue that GeoGebra, a dynamic mathematics software that combines geometry, algebra, and calculus, is an effective tool for teaching complex mathematical concepts in an interactive and visually engaging manner, in

the classroom, it enables learners to visualise and manipulate mathematical objects, enhancing learners understanding of the subject matter.

The findings also show that teachers had different perspectives on GeoGebra's effectiveness in geometry education. Teacher A just disagreed, indicating a lack of interest, knowledge, or experience. (Teachers B, C, D, E, and F), on the other hand, regard GeoGebra as a valuable tool, citing benefits. (Teachers C and D) highlight GeoGebra's ability to make complex topics more approachable and fun, while (Teacher D) provides a comprehensive review of the program's capabilities and benefits. (Teacher E) noted that GeoGebra's visual feature helps learners understand ideas more clearly, whereas (Teacher F) underlined the importance of ICT tools in making mathematics classes more engaging. (Teacher B) also acknowledged the need of using technology into instruction. These findings reflect the range of perspectives on GeoGebra's utility, with most teachers acknowledging its potential to improve teaching and learning in teaching geometry and other mathematics topics. The literature is consistent with these findings, for instance, Uwurukundo et al., (2022a, 2022b, 2022c) found that GeoGebra significantly improved learners' attitudes towards learning 3-D geometry compared to traditional methods, indicating its effectiveness in changing learners' perspectives.

Conclusion

The overarching research question guiding this study related to the perceived influences of ICT tools on the teaching of geometry in Grade 6, particularly the potential of GeoGebra to improve geometry instruction. In response to this, this study's findings revealed that most teachers have utilised ICT tools however, they encountered significant barriers while trying to acquire and use ICT into their lessons. The study demonstrates that several factors, such as teacher readiness, resource availability, and technical proficiency, influence how simple it is to implement ICT in mathematics teaching. This shows that there must be a shift towards the use of digital tools such as GeoGebra in mathematics teaching, hence, this ICT tool is very important and relevant in teaching topics like algebra, geometry, statistics etc, this software also improves learners' involvement and mathematical reasoning. These findings reflect gaps in teacher experience to and familiarity with GeoGebra, highlighting a knowledge gap among teachers, with some displaying advanced understanding and others having limited understanding. This findings reveal that, if these teachers are familiar with GeoGebra, getting a proper training may enable them to integrate it in their teaching of different mathematics topics. These findings reflect the range of perspectives on GeoGebra's utility, with most teachers acknowledging its potential to improve teaching and learning in teaching geometry and other mathematics topics.

The findings also informed the development of the GeoGebra workshop, ensuring a targeted and effective intervention. By leveraging these insights, the researcher aimed to enhance teachers' ICT integration skills, promote meaningful GeoGebra adoption, and ultimately improve Grade 6 Geometry teaching for mathematical reasoning. This study's findings contribute to the ongoing conversation on ICT integration in mathematics education, providing valuable perspectives from Buffalo City Metro and Amathole East Districts. Further, the findings offer implications for teacher training programs, highlighting the importance of contextualised support for effective ICT adoption.

Recommendations

This study's recommendations include a need for a support from Department of Education through teacher ICT training workshops, building of ICT infrastructure, providing schools with technological gadgets such as laptops and tablets, teachers' cooperation through sharing of best ICT teaching pedagogies. In addition, teachers and policymakers should develop a more sustainable and successful ICT-integrated mathematics education system that improves teaching and learning by implementing these recommendations into practice.

Limitation

The study had limitations due to time constraints, as it was conducted with the goal of earning a degree within a set timeframe. To address time restrictions, the study limited the sample size to six teachers, allowing for more manageable data collection and analysis.

References

Adelabu, F. M., Marange, I. Y., & Alex, J. (2022). GeoGebra Software to Teach and Learn Circle Geometry: Academic Achievement of Grade 11 Learners. *Mathematics Teaching Research Journal*, *14*(3), 2-16.

Ait Hammou, Y. (2021). Teachers' Most Frequently Used ICT Tools for Teaching Language Skills and Components in Moroccan Secondary School EFL Classrooms. *International Journal of Social Science and Human Research*, *4*(110), 2775-2783.

Alenezi, A., & Alsadoon, A. (2022). Teacher professional development in the digital age: Challenges and opportunities. *Education and Information Technologies,* 27(3), 3475–3490.

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

Ardina, G., Bautista, G., & delos Santos, M. S. (2025). GeoGebra Integration in Mathematics Teaching: Bridging Research and Classroom Practice. *Journal of Interdisciplinary Perspectives*, *3*(8), 845-856.

Arhin, J., Boateng, F. O., Akosah, E. F., & Gyimah, K. (2024). Perceptions and Readiness of High School Mathematics Teachers for Integration of ICT Tools in the Teaching and Learning of Mathematics. *Pedagogical research*, *9*(1).

Ashiono, B., Murungi, C. G., & Mwoma, T. (2018). Supporting teachers in their use of ICT in teaching mathematics: what kind of support is necessary and when is it required. *Int J Pregn & Chi Birth, 4(6), 247-251.*

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist*, *37*(2), 122.

Batiibwe, M. S. K. (2024). Integration of GeoGebra in learning mathematics: Benefits and challenges.

Buabeng-Andoh, C. (2012). Factors Influencing Teachers' Adoption and Integration of Information and Communication Technology into Teaching: A Review of the Literature. *International Journal of Education and Development using Information and Communication Technology (IJEDICT*), 8, 136-155.

Chakraborty, S. (2023). Overcoming barriers to ICT integration: A case study of secondary schools in India.

Educational Technology & Society, 26(1), 157–170.

Chytas, C., van Borkulo, S. P., Drijvers, P., Barendsen, E., & Tolboom, J. L. (2024). Computational thinking in secondary mathematics education with GeoGebra: Insights from an intervention in calculus lessons. *Digital Experiences in Mathematics Education*, *10*(2), 228-259.

Cohen, L., Manion, L., & Morrison, K. (2002). *Research methods in education*. routledge.

Creswell, J. W., & Plano Clark, V. L. (2023). Revisiting mixed methods research designs twenty years later. *Handbook of mixed methods research designs*, *1*(1), 21-36.

Davis, F. D. (1987). User acceptance of information systems: the technology acceptance model (TAM).

Department of Basic Education. (2024). *National Senior Certificate Report 2024*.

Filina, N. Z., Sari, S. M., & Zahraini, Z. (2024). The utilization of Technological Pedagogical Content Knowledge (TPACK) in elementary school learning. *International Journal of Business, Law, and Education*, *5*(1), 260-266.

Golding, J., & Batiibwe, M. S. K. (2020). A design approach to mathematics teacher teacher development in East Africa. *JRA Math Edu (Journal of Research and Advances in Mathematics Education)*, 6(1).

Hassan, Muhammad Nasiru, Abdullah, A. H., &Ismail, N. (2020a). Effects of IntegrativeInterventions with van Hiele Phase on Learners'Geometric Thinking: A Systimatic Review.Journal of Critical Reviews, 7(13), 1133–1140.https://doi.org/10.31838/jcr.07.13.194

Hechter, J. (2022, May). Mathematics' war-real or imaginary?. In *8th International Conference on Higher Education Advances (HEAd'22)* (pp. 539-547). Editorial Universitat Politècnica de València.

Herbert, J., Ferri, L., Hernandez, B., Zamarripa, I., Hofer, K., Fazeli, M. S., ... & Abdallah, K. (2023). Personality diversity in the workplace: A systematic literature review on introversion. *Journal of Workplace Behavioral Health*, *38*(2), 165-187.

Hsu, P. S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *Tech Trends*, *60*(1), 30-40.

Kassutto, S. M., Baston, C., & Clancy, C. (2021). Virtual, Augmented, and Alternate Reality in Medical Education*: Socially Distanced but Fully Immersed. ATS Scholar, 2(4), 651–664.*

Kibirige, I. (2023). Primary teachers' challenges in implementing ICT in Science, Technology, Engineering, and Mathematics (STEM) in the post-pandemic era in Uganda. *Education sciences*, 13(4), 382.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary issues in technology and teacher education*, *9*(1), 60-70.

Korenova, L., Schmid, A. & Demel, A. (2025). Exploring the Use of GeoGebra Software in Teaching Stereometry at Primary Schools*: An Action Research Study*.

Kunjiapu, S., Sinnappan, P., Salim, F. A. A., & Kunasegaran, M. (2025). Challenges and dilemmas of digitalization in Philippine education: A grassroots perspective. *Journal of Public Administration and Governance*, *14*(2), 232.

Lee, Y., Kozar, K. A., & Larsen, K. R. (2003). The technology acceptance model: Past, present, and future. *Communications of the Association for information systems*, *12*(1), 50.

Lepheana, L.J. & Chisango, G. (2022). Challenges of implementing inclusive education in South Africa: a case study in Buffalo City Education District. *International Journal*, 78(12/1).

Linake, M. A., Liziwe, F., & Kleinbooi, C. (2023). Framework For Improving Speaking Skills In Grade 4

English First Additional Language Learners During English Lessons In Rural Areas. In *EDULEARN23 Proceedings* (pp. 8638-8646). IATED.

Maričić, M., Anđić, B., Soeharto, S., Mumcu, F., Cvjetićanin, S., & Lavicza, Z. (2025). The exploration of continuous teaching intention in emerging-technology environments through perceived cognitive load, usability, and teacher's attitudes. *Education and Information Technologies*, *30*(7), 9341-9370.

Mokgadi, T., & Moloi, T. J. (2025). Navigating ICT Challenges and Effects at Rekopantswe Senior Phase Schools: Exploring Teaching and Learning Results. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, 9(1), 46–73.

Mthethwa, M., Bossé, M. J., Williams, D., & Bayaga, A. (2020). GeoGebra for learning and teaching: A parallel investigation. *South African Journal of Education,* 40(2), 1-12.

Mwingirwa, I. M., & Miheso-O'Connor, M. K. (2016). Status of Teachers' Technology Uptake and Use of GeoGebra in Teaching Secondary School Mathematics in Kenya. *International Journal of Research in Education and Science*, *2*(2), 286-294.

Nyakito, C., Amimo, C., & Allida, V. B. (2021). Challenges of integrating information and communication technology in teaching among National Teachers' Colleges in Uganda. *East African Journal of Education and Social Sciences,* 2(3), 157-171.

Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: results from a worldwide educational assessment. *Computers & education*, *37*(2), 163-178.

Prieto-González, J. L., Gutiérrez-Araujo, R. E., Arredondo, E. H., & Montecino, A. (2023). Contradictions in the learning of Euclidean constructions with GeoGebra by pre-service mathematics teachers. *Journal of Mathematics Teacher Education*, 1-25.

Priyanda, R., Herman, T., Amalia, R. & Ihsan, I. (2025). Exploring teachers' pedagogical reasoning in mathematics education using the TPACK framework. *Frontiers in Education*.

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A. L., Prinsloo, C. & Isdale, K. (2016). TIMSS 2015: *Highlights of mathematics and science achievement of grade 9 South African learners.* (Commissioned by the Department of Basic Education, December).

Reynolds, K. A., Aldrich, C. E. A., Bookbinder, A., Gallo, A., von Davier, M. & Kennedy, (Eds.) (2024). TIMSS 2023 Encyclopedia: Education Policy and Curriculum in Mathematics and Science. Boston College, *TIMSS & PIRLS International Study Center*.

Saralar-Aras, I., & Birgili, B. (2022). An Assessment of Pre-Service Mathematics Teachers' Techno-Pedagogical Content Knowledge Regarding Geometry. *International Journal of Psychology and Educational Studies*, *9*(4), 1307-1327.

Schmid, A. & Korenova, L. (2024). Enhancing Geometry Learning with GeoGebra: A Study. European Conference on e-Learning. 23. 487-495.

Scippo, S., Madiai, S., & Cuomo, S. (2025). Digital Tessellation for Geometry Learning in Primary School: A Quasi-Experimental Study. *Journal Of Information Technology Education*, *24*, 1-31.

Shadaan, P., & Leong, K. E. (2013). Effectiveness of Using GeoGebra on Learners' Understanding in Learning Circles. *Malaysian Online Journal of Educational Technology*, 1(4), 1-11.

Sulianto, J., Sunardi, S., Anitah, S. & Gunarhadi, G. (2020). Classification of Learner Reasoning Skills in Solving Mathematics Problems in Elementary School. *JPI Jurnal Pendidikan Indonesia,* 9 (1), 95.

Suparman, S., Marasabessy, R., & Helsa, Y. (2024). Fostering spatial visualization in GeoGebra-assisted geometry lesson: A systematic review and meta-analysis. Eurasia Journal of Mathematics, Science and Technology Education, 20(9), Article em2509.

Thomas, A. O., & Adebowale, A. M. (2023). Geogebra Software: Synergy That Improves Performance in Geometry Learning in Ogbomoso Education Zone of Oyo State. *African Journal of Education and Practice*, 9(4), 1–14.

Tondeur, J., Van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational technology research and development*, *65*(3), 555-575.

Uwurukundo, M. S., Maniraho, J. F., & Tusiime Rwibasira, M. (2022). Effect of GeoGebra software on secondary school learners' achievement in 3-D geometry. *Education and Information Technologies*, *27*(4), 5749-5765.

Yunianto, W., Jarvis, D., Lavicza, Z., Putra, Z. H., & El-Bedewy, S. (2025). Primary school learners' problem-solving strategies in creating artworks with GeoGebra: Integrating computational thinking skills into mathematics and visual arts lessons. *LUMAT: International Journal on Math, Science and Technology Education*, *13*(2), 1-1.

Author Information

Lepheana Justice Lepheana
https://orcid.org/0009-0004-5104-000X
Deputy principal
Sol Plaatje University
South Africa

Jabulani Sibanda
https://orcid.org/0000-0001-5328-5888
Associate Professor
Rhodes University
South Africa
Contact e-mail: *Jabulani.Sibanda@ru.ac.za*