



Effect of Innovative Teaching Methods on Students' Mathematics Self-Efficacy Beliefs in Three-Dimensional Geometry in Public Day Secondary Schools in Musanze District, Rwanda

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Abstract: The paper reports findings of a study that sought to examine the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry in public day secondary schools in Musanze District, Rwanda. The study was based on Self-Efficacy Theory and Social Cognitive Theory. A mixed-methods research design employing quasi-experimental and descriptive approaches was used for the study. Multistage sampling techniques were used to select a sample of 269 students from public day secondary schools in Musanze District. Students' mathematics self-efficacy questionnaires, achievement tests, and semi-structured interview guides were used to collect data from respondents. Quantitative data were analyzed using descriptive statistics and an independent samples t-test, while qualitative data were analyzed thematically. The results indicate that students exposed to innovative teaching methods attained slightly higher mathematics self-efficacy scores than students taught using traditional instructional approaches. However, the difference was not statistically significant, indicating that innovative teaching methods did not significantly influence students' mathematics self-efficacy beliefs in three-dimensional geometry. The study provides a basis upon which mathematics teachers, curriculum developers, and educational policymakers can strengthen learner-centered instructional approaches and create supportive learning environments that promote students' confidence, motivation, and participation in mathematics learning.

Keywords: Innovative Teaching Methods, Mathematics Self-Efficacy, Three-Dimensional Geometry, Inquiry-Based Learning, Guided Discovery Learning, GeoGebra, SketchUp

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1.Introduction

Mathematics is widely recognized as a fundamental discipline for developing analytical thinking, logical reasoning, and problem-solving abilities that are essential

for success in modern knowledge-based societies (Flores-Bascuñana et al., 2020). The subject provides learners with critical competencies required for scientific inquiry, technological advancement, and informed decision-making in everyday life. As education systems increasingly emphasize the development of twenty-first-

century skills, mathematics continues to serve as a foundation for innovation, creativity, and economic transformation (Anderson & Krathwohl, 2021). In addition, mathematics contributes significantly to the development of critical thinking and higher-order cognitive skills required in Science, Technology, Engineering, and Mathematics (STEM) disciplines (Mayer, 2022; Hattie, 2023).

Among the various branches of mathematics, three-dimensional (3D) geometry remains one of the most challenging areas for secondary school learners because it requires advanced visualization, spatial reasoning, and conceptual understanding of geometric relationships. Students are expected to mentally manipulate objects, interpret diagrams, understand spatial transformations, and apply geometric principles to solve complex problems. However, many learners experience difficulties in visualizing and reasoning about three-dimensional objects, leading to persistent misconceptions and poor academic outcomes (Pinilla, 2024; Battista, 2019). Research further indicates that traditional instructional approaches often fail to adequately support learners in developing the conceptual understanding and spatial reasoning skills necessary for successful learning of 3D geometry (Kavanagh, Richmond, & Rainey, 2020; Uttal, Miller, & Newcombe, 2022).

In many educational systems across the world, innovative teaching methods have increasingly been adopted to address challenges associated with the teaching and learning of geometry. Countries such as the United States, Australia, Finland, and the United Kingdom have integrated technology-supported and learner-centered pedagogies to improve students' understanding of complex mathematical concepts. These approaches emphasize active learning, collaboration, inquiry, exploration, and visualization through the use of instructional technologies such as GeoGebra and SketchUp (Kavanagh, Richmond, & Rainey, 2020; Pinilla, 2024). Studies conducted in these contexts have demonstrated that innovative teaching methods enhance students' conceptual understanding, engagement, and confidence in mathematics learning by providing opportunities for meaningful interaction with abstract concepts (Martin, 2023; Tinker & Krajcik, 2021).

Within the African context, mathematics education continues to face significant challenges despite ongoing educational reforms aimed at improving learning outcomes. In many countries, including Kenya, Uganda, Nigeria, and Rwanda, mathematics instruction remains largely dominated by teacher-centered approaches characterized by lecture-based delivery and passive student participation. Such approaches often limit

opportunities for conceptual exploration, problem-solving, and collaborative learning, thereby affecting students' understanding of abstract concepts such as three-dimensional geometry (Adu-Gyamfi & Brenya, 2019; Zuze & Hu, 2019). Although several countries have initiated efforts to integrate technology and learner-centered pedagogies into mathematics classrooms, inadequate infrastructure, limited access to digital resources, and insufficient teacher training continue to hinder effective implementation (African Union, 2020; Mutonyi & Norton, 2021).

In Rwanda, the teaching and learning of three-dimensional geometry remains a significant concern, particularly in public day secondary schools located in rural areas. According to the Rwanda Education Board, only 31.4% of students correctly answered three-dimensional geometry questions in national Ordinary Level mathematics examinations. These questions required learners to interpret geometric diagrams, visualize spatial relationships, and calculate geometric measurements such as volume and surface area, competencies that many students found difficult to master (Nzabonimpa & Uwizeyimana, 2023; REB, 2022). The situation is more pronounced in districts such as Musanze, where schools continue to face challenges related to inadequate instructional resources, limited access to ICT infrastructure, and insufficient teacher preparedness in the use of innovative instructional approaches (Mpumuje, 2024; Nkuyubwatsi, Rwampyemana, & Uwizeyimana, 2022).

Besides academic achievement, students' beliefs about their capabilities play a critical role in determining learning outcomes in mathematics. Mathematics self-efficacy refers to learners' judgments about their ability to successfully perform mathematical tasks and solve mathematical problems. Students with high mathematics self-efficacy tend to demonstrate greater persistence, stronger motivation, and higher levels of engagement when confronted with challenging learning tasks. Conversely, students with low self-efficacy often experience anxiety, reduced confidence, and reluctance to participate actively in mathematics learning activities (Dweck, 2020; Schunk, 2020). Research has consistently shown that students' beliefs about their mathematical capabilities significantly influence both their learning behaviours and academic achievement (Van der Graaf, Segers, & Verhoeven, 2022; Maltese & Tai, 2021).

Innovative teaching methods have been identified as effective approaches for enhancing students' mathematics self-efficacy because they promote active participation, collaborative learning, inquiry, exploration, and meaningful engagement with mathematical concepts.

Inquiry-based learning enables students to investigate mathematical relationships and construct knowledge through exploration, while guided discovery learning provides structured opportunities for learners to discover concepts through carefully designed activities. Similarly, technology-enhanced learning environments supported by GeoGebra and SketchUp allow learners to visualize, manipulate, and explore three-dimensional geometric objects dynamically, thereby strengthening their understanding and confidence in mathematics (Martin, 2023; Yoon, Liu, & Schott, 2023). Furthermore, these instructional approaches have been associated with improvements in students' motivation, engagement, conceptual understanding, and mathematics self-efficacy across different educational contexts (Zepeda, Martin, & Butler, 2019; Putri & Musdi, 2024).

Despite growing evidence regarding the benefits of innovative teaching methods, empirical studies examining their influence on students' mathematics self-efficacy in three-dimensional geometry remain limited within the Rwandan context, particularly in rural public day secondary schools. Existing studies have primarily focused on academic achievement, technology integration, or instructional effectiveness without specifically investigating how innovative teaching methods influence learners' confidence and beliefs regarding their mathematical capabilities in geometry learning (Rubagiza, Were, & Sutherland, 2011; Uwurukundo, Niyigena, & Habimana, 2022). This creates a contextual and empirical gap that necessitates further investigation. Therefore, this study sought to examine the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry in public day secondary schools in Musanze District, Rwanda.

1.2. Objectives of the Study

The study sought to investigate the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry in public day secondary schools in Musanze District, Rwanda. Specifically, it aimed to determine the effect of inquiry-based learning, guided discovery learning, and the integration of GeoGebra and SketchUp on students' mathematics self-efficacy in three-dimensional geometry.

2. Literature Review

This section reviews literature related to innovative teaching methods and students' mathematics self-efficacy in three-dimensional geometry. The review focuses on inquiry-based learning, guided discovery learning, and the

integration of GeoGebra and SketchUp as innovative instructional approaches. It also examines how these approaches may influence students' confidence, motivation, persistence, and perceived capability in performing mathematical tasks. The review is guided by the view that students' mathematics self-efficacy develops through active learning experiences, successful task performance, interaction with peers, feedback, and supportive learning environments.

2.1. Conceptual Review

Innovative teaching methods have increasingly received attention in mathematics education because of their potential to improve students' engagement, conceptual understanding, reasoning, and confidence in learning. Unlike traditional teacher-centered approaches, innovative methods emphasize active participation, exploration, collaboration, inquiry, and the use of appropriate instructional technologies. In mathematics education, these approaches are particularly relevant to areas such as three-dimensional geometry, where students are required to visualize objects, understand spatial relationships, and apply geometric concepts to solve problems. Kavanagh, Richmond, and Rainey (2020) emphasize the importance of collaborative inquiry and technology integration in mathematics teaching, while Martin (2023) highlights the contribution of dynamic geometry software to students' spatial reasoning. These approaches may therefore provide learners with experiences that support both mathematical understanding and positive beliefs about their capabilities.

Inquiry-based learning is one of the innovative approaches that can support students' involvement in mathematics learning. It encourages learners to investigate questions, explore mathematical relationships, identify patterns, and develop solutions through active participation. In three-dimensional geometry, inquiry-based learning can provide students with opportunities to investigate geometric objects and relationships rather than depending entirely on teacher explanations. Van der Graaf, Segers, and Verhoeven (2022) reported that inquiry-based learning can contribute to students' conceptual understanding and reasoning skills, while Putri and Musdi (2024) found that guided inquiry can improve mathematical reasoning abilities. Through active investigation and problem-solving, students may develop greater confidence in their ability to perform mathematical tasks. However, the development of self-efficacy may require repeated successful learning experiences because students' beliefs about their capabilities do not necessarily change immediately following the introduction of a new instructional approach.

Guided discovery learning is another learner-centered approach relevant to mathematics education. It allows students to discover mathematical concepts and relationships through structured learning activities while receiving appropriate guidance from teachers. The approach provides learners with opportunities to explore mathematical ideas and solve problems while reducing the possibility of becoming completely unsupported during the discovery process. Zepeda, Martin, and Butler (2019) associated guided discovery learning with active participation and motivation, suggesting that the approach can create learning conditions that encourage students to become more involved in the learning process. In three-dimensional geometry, guided discovery may enable students to investigate geometric properties, develop spatial understanding, and gradually gain confidence through successful completion of mathematical tasks. Schunk (2020) further emphasizes the importance of feedback, practice, and successful learning experiences in the development of students' confidence. This suggests that guided discovery may contribute to mathematics self-efficacy when it is implemented consistently and provides learners with sufficient opportunities to experience success.

The integration of technology in mathematics teaching is also considered an important component of innovative instruction. In particular, GeoGebra and SketchUp can provide dynamic representations that enable students to visualize and manipulate three-dimensional geometric objects. This is important because three-dimensional geometry requires learners to mentally represent objects and understand relationships that may be difficult to communicate through static diagrams alone. Kavanagh, Richmond, and Rainey (2020) examined the integration of technology into geometry teaching, while Martin (2023) highlighted the potential of dynamic geometry software to support spatial reasoning. Similarly, Yoon, Liu, and Schott (2023) examined technology-supported learning in geometry and reported its relevance to student engagement and learning outcomes. Through manipulation and visualization of geometric objects, learners may obtain clearer understanding of abstract concepts and develop greater confidence in their ability to solve geometry problems.

Despite the potential benefits of technology-supported instruction, the effectiveness of GeoGebra and SketchUp depends on the learning environment in which they are implemented. Access to technological resources, teacher preparedness, and the ability to integrate digital tools with appropriate pedagogical strategies can influence the effectiveness of technology-supported mathematics instruction. Rubagiza, Were, and Sutherland (2011) identified both challenges and opportunities associated

with ICT integration in Rwandan schools, while Nkuyubwatsi, Rwampyemana, and Uwizeyimana (2022) highlighted issues related to teacher readiness for digital mathematics instruction. Therefore, the use of technology does not automatically result in stronger mathematics self-efficacy. Rather, students need meaningful opportunities to interact with digital tools, receive appropriate guidance, and experience successful learning outcomes.

Mathematics self-efficacy is particularly important because students' beliefs about their ability to perform mathematical tasks can influence their motivation, persistence, participation, and response to challenging problems. Students who believe that they are capable of solving mathematical problems are more likely to persist when they encounter difficulties, whereas students with weak self-efficacy may avoid challenging tasks or withdraw from participation. The manuscript identifies self-efficacy as an important factor in mathematics learning and relates it to students' confidence, motivation, persistence, and perceived capability in solving three-dimensional geometry tasks. Schunk (2020) emphasizes that students' confidence can develop through practice, feedback, and successful experiences, while Bandura's Social Cognitive Theory explains that personal beliefs interact with behaviour and environmental conditions to influence learning (Bandura, 1986).

The relationship between innovative teaching methods and mathematics self-efficacy can therefore be understood through the learning experiences created by these instructional approaches. Inquiry-based learning can give students opportunities to investigate and solve problems, guided discovery can allow them to experience successful discovery with appropriate support, and GeoGebra and SketchUp can make abstract geometric concepts more visible and interactive. These experiences may contribute to stronger beliefs in students' mathematical capabilities. However, the effect of innovative teaching methods on self-efficacy may depend on the duration and consistency of implementation. Simonsmeier, Flaig, and Schneider (2022) noted the importance of sustained learner-centered learning experiences, while the findings presented in the current study suggest that a relatively short intervention may not be sufficient to generate statistically significant changes in students' mathematics self-efficacy.

Although previous studies have examined innovative teaching methods, technology integration, mathematical reasoning, spatial understanding, and academic achievement, limited attention has been given to the specific influence of these approaches on students' mathematics self-efficacy in three-dimensional geometry within the Rwandan context. Existing studies cited in the manuscript have addressed issues such as ICT integration,

teacher readiness, and mathematics teaching challenges in Rwanda, but they have not sufficiently examined whether innovative teaching methods significantly influence students' beliefs about their ability to perform three-dimensional geometry tasks. This creates a contextual and empirical gap that the present study seeks to address by examining the effect of inquiry-based learning, guided discovery learning, and the integration of GeoGebra and SketchUp on students' mathematics self-efficacy in public day secondary schools in Musanze District, Rwanda

2.3. Theoretical Framework

The study was further guided by Social Cognitive Theory (SCT) developed by Bandura (1986). The theory explains that learning occurs through the reciprocal interaction of personal factors, behavioural factors, and environmental influences. According to Bandura (1986), individuals acquire knowledge, skills, attitudes, and beliefs by observing others, interacting with their environment, and reflecting on the outcomes of their actions. The theory emphasizes that human behaviour is shaped not only by external environmental conditions but also by individuals' perceptions, beliefs, expectations, and self-regulatory processes.

Social Cognitive Theory is relevant to this study because innovative teaching methods create learning environments that encourage active participation, collaboration, observation, and interaction among learners. Through inquiry-based learning, guided discovery learning, and technology-supported instruction using GeoGebra and SketchUp, students are exposed to opportunities for exploration, peer learning, problem-solving, and feedback. These experiences enable learners to develop confidence in their mathematical abilities and strengthen their beliefs regarding successful performance in three-dimensional geometry tasks.

Bandura (1986) further argues that self-efficacy is a central component of Social Cognitive Theory because individuals' beliefs about their capabilities influence their motivation, effort, persistence, and performance. In mathematics learning, students with strong self-efficacy beliefs are more likely to participate actively, persist in solving challenging problems, and achieve positive learning outcomes. Consequently, Social Cognitive Theory provides a useful framework for understanding how innovative teaching methods influence students' mathematics self-efficacy in three-dimensional geometry.

2.4. Empirical Review

Empirical studies have examined the relationship between innovative teaching approaches and students' learning

experiences in mathematics and other related disciplines. The evidence generally indicates that learner-centered approaches such as inquiry-based learning and guided discovery can improve students' engagement, reasoning, conceptual understanding, and motivation. However, the extent to which these approaches influence students' mathematics self-efficacy, particularly in three-dimensional geometry, remains less clear. This section therefore reviews empirical evidence related to inquiry-based learning, guided discovery learning, and technology-supported mathematics instruction, with particular attention to their implications for students' confidence and perceived mathematical capability.

Van der Graaf, Segers, and Verhoeven (2022) examined the effects of inquiry-based learning on students' academic achievement through a meta-analysis of educational studies. Their findings indicated that inquiry-based learning can contribute positively to students' learning by involving learners actively in investigation, reasoning, and problem-solving. The study is relevant to the present research because active involvement in mathematical tasks can provide students with opportunities to develop mastery experiences, which are important for strengthening self-efficacy. However, the study primarily focused on academic achievement rather than mathematics self-efficacy in three-dimensional geometry. The present study therefore extends this line of inquiry by examining students' beliefs about their mathematical capabilities within a specific geometry context.

Putri and Musdi (2024) investigated the effectiveness of guided inquiry in improving students' mathematical reasoning abilities. Their findings indicated that guided inquiry can support students' mathematical reasoning by encouraging learners to explore problems, formulate ideas, and develop solutions through active participation. These findings suggest that learner-centered inquiry may create classroom experiences that support confidence and engagement in mathematics. Nevertheless, the study focused mainly on mathematical reasoning rather than students' mathematics self-efficacy. Consequently, it does not establish whether improved reasoning resulting from guided inquiry is accompanied by statistically significant changes in students' beliefs about their ability to perform mathematical tasks.

Zepeda, Martin, and Butler (2019) examined the role of guided discovery learning in science education through a meta-analysis. The study reported that guided discovery can promote active participation and motivation when learners are provided with appropriate instructional support. The findings are relevant to the present study because motivation and active participation are closely

associated with students' willingness to engage with challenging mathematical tasks. In three-dimensional geometry, guided discovery may enable students to investigate geometric relationships and develop understanding through structured exploration. However, the study was conducted in science education rather than specifically in mathematics or three-dimensional geometry, creating a contextual gap that the present study seeks to address.

Simonsmeier, Flaig, and Schneider (2022) examined inquiry-based learning and achievement and reported that learner-centered instructional approaches can support students' engagement and learning outcomes. Their findings suggest that students benefit from learning environments in which they are actively involved in constructing knowledge. The relevance of this study to the present research lies in the possibility that sustained participation in inquiry activities may provide students with repeated opportunities to experience success, receive feedback, and develop confidence. However, the available evidence from this study does not directly establish the effect of inquiry-based learning on mathematics self-efficacy in three-dimensional geometry, particularly among secondary school students in Rwanda.

Technology-supported instruction has also been examined as an approach to improving mathematics learning. Kavanagh, Richmond, and Rainey (2020) examined teacher learning through collaborative inquiry and the integration of technology into geometry teaching. Their work highlights the importance of integrating technology with pedagogical approaches that actively involve learners in the learning process. Martin (2023) similarly examined the use of dynamic geometry software to enhance spatial reasoning in secondary mathematics. The findings reported in these studies support the use of technology to make geometric concepts more interactive and support learners' understanding of spatial relationships. However, the studies provide limited direct evidence concerning whether the use of tools such as GeoGebra and SketchUp significantly improves students' mathematics self-efficacy.

Yoon, Liu, and Schott (2023) examined the use of augmented reality as a learning tool in geometry education, focusing on student engagement and learning outcomes. Their findings demonstrate the potential of technology-supported environments to increase students' interaction with geometric concepts. Such environments are relevant to three-dimensional geometry because they can provide learners with visual and interactive representations of mathematical objects. Nevertheless, engagement and learning outcomes are different from mathematics self-efficacy. Therefore, while the study

provides support for the potential value of technology in geometry instruction, it does not fully explain whether technology-supported instruction changes students' beliefs about their ability to solve geometry problems.

Evidence from the Rwandan context also identifies challenges that may influence the implementation of innovative mathematics teaching approaches. Rubagiza, Were, and Sutherland (2011) examined the introduction of ICT into schools in Rwanda and identified both opportunities and challenges associated with educational technology integration. Similarly, Nkuyubwatsi, Rwampyemana, and Uwizeyimana (2022) examined teacher readiness for digital mathematics instruction in Rwandan secondary schools and highlighted the importance of teacher preparedness in the effective use of digital technologies. These studies demonstrate that the effectiveness of technology-supported instruction cannot be considered separately from the availability of resources and teachers' capacity to use technology effectively. However, they do not directly examine the relationship between innovative teaching methods and students' mathematics self-efficacy in three-dimensional geometry

3. Methodology

This study adopted mixed-methods research design grounded in the pragmatic research paradigm. Specifically, the study employed a quasi-experimental design and a descriptive research design to investigate the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry in public day secondary schools in Musanze District, Rwanda. The quasi-experimental design was used to compare students exposed to innovative teaching methods with those taught using traditional teaching methods, while the descriptive design facilitated the collection of supplementary information regarding students' perceptions and experiences during the intervention.

The study was conducted in Musanze District in the Northern Province of Rwanda. The target population comprised 2,219 students and 50 mathematics teachers drawn from public day secondary schools. Using multistage sampling techniques and the Yamane formula, a sample of 269 students was selected to participate in the study, while all 50 mathematics teachers were included through a census sampling technique. The study involved Senior Four, Senior Five, and Senior Six students studying three-dimensional geometry.

Innovative teaching methods constituted the independent variable and were operationalized through the integration of GeoGebra and SketchUp, inquiry-based learning, and

guided discovery learning. The dependent variable was students' mathematics self-efficacy in three-dimensional geometry. Data were collected using a Students' Mathematics Self-Efficacy Questionnaire, achievement tests, and semi-structured interview guides. The questionnaire measured students' confidence, persistence, motivation, and perceived capability in solving three-dimensional geometry tasks. Prior to the main study, a pilot study was conducted to establish the validity and reliability of the research instruments. Content validity was assessed through expert review, while reliability was determined using appropriate statistical procedures.

Quantitative data were analyzed using descriptive statistics and an independent samples t-test to determine whether significant differences existed in mathematics self-efficacy between students taught using innovative teaching methods and those taught using traditional teaching methods. Qualitative data obtained through interviews were analyzed thematically and used to complement the quantitative findings. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), and all hypotheses were tested at the 0.05 level of significance

4. Results and Discussion

This section presents the findings of the study on the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry in public day secondary schools in Musanze District, Rwanda. The findings are presented based on the study objective, which sought to determine the effect of inquiry-based learning, guided discovery learning, and the

integration of GeoGebra and SketchUp on students' mathematics self-efficacy. The quantitative findings are presented using descriptive statistics and an independent samples t-test, while the discussion relates the findings to empirical literature and the theoretical framework of the study.

4.1. Findings

The study targeted 269 students from public day secondary schools in Musanze District. The sample comprised 132 students in the Experimental Group and 137 students in the Control Group. The manuscript indicates that these 269 students participated in the study and that the analysis was based on their responses. The study examined the effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry. Students' mathematics self-efficacy was assessed using a composite score covering their confidence, motivation, persistence, and perceived capability to solve three-dimensional geometry tasks. The analysis compared students who were exposed to innovative teaching methods with those who were taught using traditional instructional approaches

4.1.1. Students' Mathematics Self-Efficacy in Three-Dimensional Geometry

To establish students' levels of mathematics self-efficacy, descriptive statistics were computed for both the Experimental Group and the Control Group. The Students' Mathematics Self-Efficacy Composite Score was analyzed using means and standard deviations. The results are presented in Table 1.

Table 1: Group Statistics for Students' Mathematics Self-Efficacy

	Treatment Group	N	Mean	Std. Deviation	Std. Error Mean
Students' Mathematics Self-Efficacy Composite Score	Experimental Group	132	75.52	8.486	.739
	Control Group	137	74.74	8.070	.690

Source: Field data, 2026

As indicated in Table 1, students exposed to innovative teaching methods recorded a higher mean mathematics self-efficacy score ($M = 75.52$, $SD = 8.486$) than students taught using traditional teaching methods ($M = 74.74$, $SD = 8.070$). The results suggest that students in the Experimental Group demonstrated slightly higher levels of confidence, motivation, and belief in their ability to learn and solve three-dimensional geometry problems than their counterparts in the Control Group. However, the small difference between the mean scores indicates that the two groups exhibited relatively similar levels of mathematics self-efficacy. Therefore, further statistical analysis using an Independent Samples t-test was

conducted to establish whether the observed difference was statistically significant.

4.1.2. Independent Samples t-Test Results

To determine whether innovative teaching methods significantly influenced students' mathematics self-efficacy in three-dimensional geometry, an Independent Samples t-test was conducted. The analysis sought to establish whether the difference observed between the Experimental Group and the Control Group was statistically significant. The results are presented in Table 2.

Table 2: Independent Samples t-Test for Students' Mathematics Self-Efficacy

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Students' Mathematics Self-Efficacy Composite Score	Equal variances assumed	.083	.773	.771	267	.441	.778	1.009	-1.209	2.766
	Equal variances not assumed			.770	264.976	.442	.778	1.010	-1.211	2.768

Source: Field data, 2026

As indicated in Table 2, Levene's Test for Equality of Variances produced an F statistic value of .083 with a significance value of .773. Since the significance value is greater than .05, the assumption of equal variances was satisfied. Therefore, the "Equal Variances Assumed" results were used for interpretation of the Independent Samples t-test findings.

Examining the t-statistic for the variable, it can be seen that it is associated with a significance value of .441. Since the significance value is greater than .05, the null hypothesis, which stated that there is no statistically significant effect of innovative teaching methods on students' mathematics self-efficacy in three-dimensional geometry, was accepted. This indicates that innovative teaching methods did not significantly influence students' mathematics self-efficacy in three-dimensional geometry.

The mean difference of .778 indicates that students exposed to innovative teaching methods obtained slightly higher mathematics self-efficacy scores than students taught using traditional teaching methods. However, the difference was not statistically significant. Therefore, innovative teaching methods were not a significant determinant of students' mathematics self-efficacy in three-dimensional geometry among public day secondary schools in Musanze District, Rwanda.

4.2. Discussion of Findings

The findings of this study revealed that students who were taught using innovative teaching methods attained slightly higher mathematics self-efficacy scores than those who received traditional instructional approaches. Although the experimental group demonstrated greater confidence, motivation, and belief in their ability to solve three-dimensional geometry problems, the difference between

the two groups was not statistically significant. This suggests that inquiry-based learning, guided discovery learning, and the integration of GeoGebra and SketchUp created more engaging learning experiences that encouraged positive perceptions of mathematical ability, but the duration of the intervention may not have been sufficient to produce statistically significant changes in students' self-efficacy. These findings are consistent with those of Putri and Musdi (2024), who reported that learner-centered instructional approaches enhance students' confidence and engagement in mathematics learning. Similarly, Zepeda, Martin, and Butler (2019) found that guided discovery learning promotes active participation and motivation, thereby creating learning environments that support the development of positive attitudes towards mathematics.

The findings also agree with those of Van der Graaf, Segers, and Verhoeven (2022), who established that inquiry-based learning improves students' conceptual understanding and reasoning skills, while improvements in self-efficacy tend to emerge gradually through continuous learning experiences. Likewise, Simonsmeier, Flaig, and Schneider (2022) observed that learner-centered instructional approaches increase students' engagement and participation, although measurable changes in confidence often require sustained instructional support and repeated opportunities for successful task completion. The absence of a statistically significant difference in the present study may therefore indicate that the intervention period was too short for students to accumulate sufficient mastery experiences capable of producing substantial improvements in their mathematics self-efficacy.

The findings are further explained by Social Cognitive Theory (Bandura, 1986), which posits that learning occurs

through the reciprocal interaction of personal factors, behaviour, and the learning environment. The innovative teaching methods employed in this study provided opportunities for students to observe, interact, collaborate, and actively construct mathematical knowledge using technology-supported learning environments. Such experiences are expected to promote positive beliefs about learning by encouraging greater participation and meaningful engagement with mathematical concepts. However, because students' beliefs and behaviours develop progressively through continuous interaction with supportive learning environments, the relatively short intervention may have limited the extent to which innovative teaching methods influenced mathematics self-efficacy. This interpretation is further supported by Schunk (2020), who argues that students develop stronger confidence when they receive continuous feedback, repeated practice, and opportunities to experience success while learning.

5. Conclusion and Recommendations

This section presents the main conclusion drawn from the study findings and provides recommendations based on the evidence regarding innovative teaching methods and students' mathematics self-efficacy in three-dimensional geometry.

5.1. Conclusion

The study concludes that innovative teaching methods, including inquiry-based learning, guided discovery learning, and technology-supported instruction through GeoGebra and SketchUp, resulted in slightly higher mathematics self-efficacy scores among students exposed to the innovative approaches than among those taught using traditional methods. However, the difference was not statistically significant. Therefore, the study concludes that innovative teaching methods did not have a statistically significant effect on students' mathematics self-efficacy in three-dimensional geometry. Nevertheless, the slightly higher scores observed in the experimental group suggest that learner-centered approaches may have potential to support students' confidence, motivation, and perceived mathematical capability when implemented consistently over a sufficient period. The development of mathematics self-efficacy should therefore be viewed as a gradual process requiring continuous learner engagement, repeated opportunities for successful task completion, appropriate feedback, and sustained exposure to supportive learning environments.

5.2. Recommendations

Based on the findings and conclusion of the study, the following recommendations are made:

- 1) Mathematics teachers should continue integrating inquiry-based learning, guided discovery learning, GeoGebra, and SketchUp into three-dimensional geometry lessons. Although the study did not find a statistically significant effect, the experimental group recorded slightly higher self-efficacy scores, suggesting that these approaches may provide supportive learning experiences.
- 2) Schools should provide teachers with adequate instructional resources and opportunities to use digital technologies effectively. Access to appropriate ICT facilities and geometry software can support the visualization and exploration of three-dimensional concepts.
- 3) Mathematics teachers should provide students with repeated opportunities to solve geometry problems, receive constructive feedback, and experience successful task completion. Such continuous experiences may gradually strengthen students' confidence in their mathematical abilities.
- 4) Education authorities and curriculum developers should support sustained implementation of learner-centered instructional approaches rather than treating innovative teaching methods as short-term interventions. Teachers should be adequately supported in integrating innovative methods into regular mathematics instruction.
- 5) Future researchers should conduct longitudinal or longer-term studies to determine whether sustained exposure to innovative teaching methods produces significant changes in students' mathematics self-efficacy. Future studies could also examine other factors that may influence self-efficacy, including teacher preparedness, availability of ICT resources, duration of intervention, and students' prior mathematics ability.

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